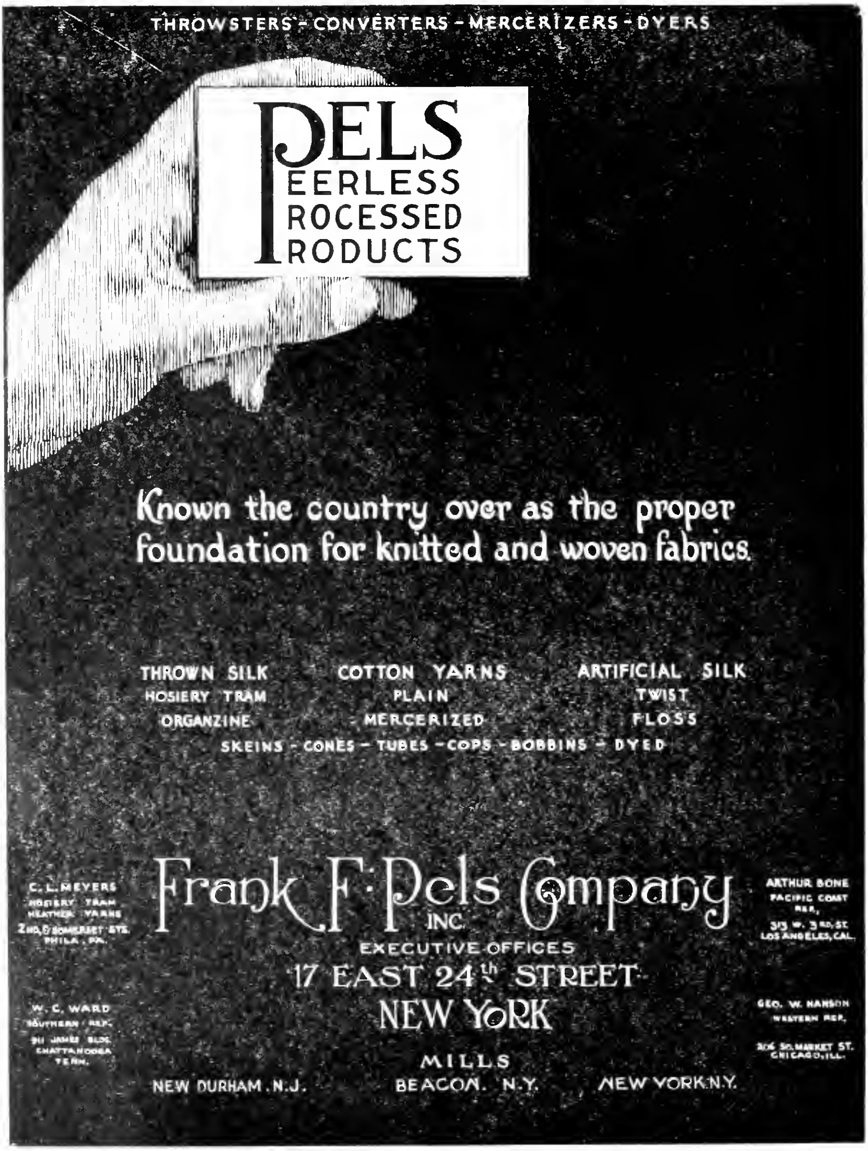
RAW SILK PROPERTIES
CLASSIFICATION OF RAW SILK
SILK THROWING

WARREN P. SEEM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AND

SILK THROWING

BY

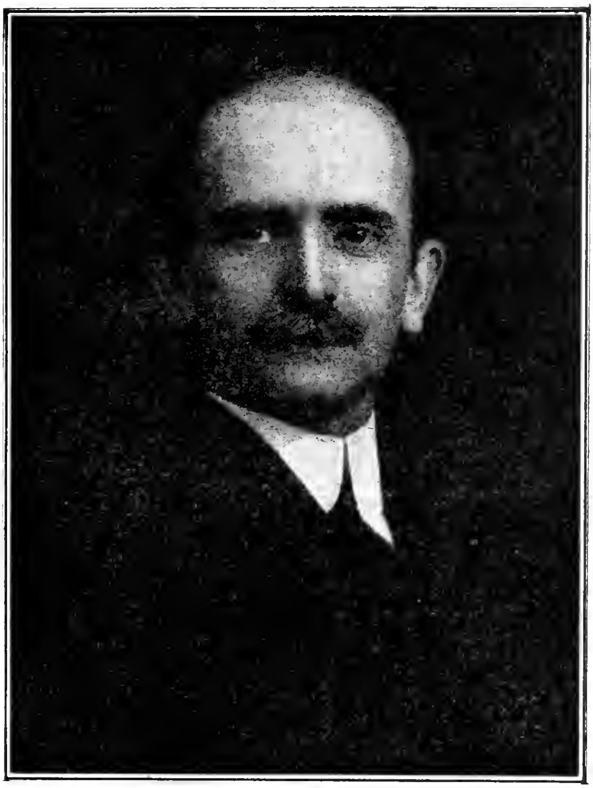
WARREN P. SEEM

PUBLISHED BY

SILK PUBLISHING COMPANY

267 FIFTH AVENUE, NEW YORK

Printed by
THE BARNES PRINTING CO., INC.
229 West 28th Street, New York, U. S. A.



Warren P. Seem

Authorized Distribution to
Mr Sharp
J. Kraske

INTRODUCTION

I AM presenting with this treatise on Silk Throwing the physical properties, structural qualities, and the classification of raw silk as found in researches and experiments by the Author.

I have aimed to gather in this volume the necessary information required to form a clear conception of the characteristics of raw silk, how to measure each quality so that one may know how to handle it properly and get efficient results.

I propose to give a basis for scientific management and break away from traditional methods and finger and thumb rule. I desire to acknowledge the assistance of many friends in proving and checking my work with actual mill practice and quality of fabrics. I do not presume to have exhausted the subjects dwelt upon, but have only taken an advance step, which I sincerely hope will point out a better way to others. I deem it proper that I should further acknowledge the financial aid and facilities provided by those interested in the subject, and which have made possible the conclusions herein presented.

WARREN P. SEEM

Richmond Hill, N. Y. City, 1922.

CONTENTS

PART I—CHAPTER I

RAW SILK PROPERTIES

I DEEM it expedient to open this chapter with a general or popular treatise on the characteristics of raw silk, that one may get a comprehensive view of the properties of the raw silk thread and thus lead up to a technical consideration by authorities on the subject.

The raw silk of commerce is received in skeins weighing from two and a half to three and a half ounces, and the size mostly used contains from 45,000 to 65,000 yards per skein or from 300,000 to 320,000 yards to the pound. A perfect skein of raw silk is considered as one of continuous length knotted together with knots not over one-eighth of an inch in length, and free from defects larger than the average diameter of the thread.

The popular size, called 13/15 denier, is about 0.00217″ in diameter and requires about 500 threads to cover one inch. The thread may vary twenty per cent in diameter on the best qualities and yet be considered a good delivery. The thread is not as uniform in size as cotton and cannot be measured with a micrometer caliper like wire, first, because it yields under pressure, and second, because every few inches it changes in diameter. The international method of determining the size is to reel a skein of 450 meters and weigh this in units of .05 grams called a denier.

The raw silk thread, as generally known, is the product of a worm that feeds on mulberry leaves and is called Bombyx Mori, or mulberry silkworm. In the cycle of life of the silkworm, the egg, which is about the size of a pin head, hatches out into a worm about one-eighth of an inch long, which grows to about three inches in length in one month's time, then spins a cocoon of silken fibres around itself, changes shortly into a chrysalis which in a few days is transformed into a moth; when the moth lays its eggs the cycle of life is completed. One ounce of eggs produces about 150 pounds of cocoons.

The cocoon filament varies in size from 3.20 deniers on the exterior of the cocoon to 1.92 deniers on the interior of the cocoon, or an average of about 2.50 deniers. Different races give different sizes. The cocoon fibre consists of two filaments which issue from two small orifices in the head of the worm in a glutinous state and harden immediately on exposure to the air. From seventeen to twenty-five per cent of this fibre is a silk gum or glue called sericin, and the remaining portion is the real fibre called fibroin. The cocoon fibre is about 0.00043″ in diameter, or requires about 2500 fibres laid side by side to cover one inch.

To secure the thread of commerce the cocoons are soaked in boiling water which softens the gum and permits of the unwinding of the cocoon fibre; five or six of these cocoon fibres are then brought together and caused to wind or

twist around each other from twelve to twenty times, so as to cause these fibres to press and knead together into one compact thread as well as to wring out the water and cause the thread to cohere together firmly before reaching the reel, where they are reeled into the skein of commerce.

The proper cementing of these fibres is one of the important qualities of the silk thread, and is called cohesion. The irregular size of the cocoon fibres prevents the reeling of an absolutely even size thread, and it is altogether a matter of judgment when one or more threads are required to keep the thread up to size; in fact, it is only when the threads appear thinner that an additional fibre is cast in on the running thread. The cocoons contain from 500 to 700 yards and it requires from 2500 to 3000 cocoons to reel a pound of silk.

Three crops of cocoons are produced in Japan. The first are called Spring, which are set to hatch early in May, when a sufficient number of mulberry leaves begin to sprout forth, and are generally ready for reeling early in June. The eggs for the second or Summer crop are held over in cold storage until the middle of June, and these are ready for reeling about the end of July. The third crop, known as Autumn crop, are taken out of cold storage about the middle of July and are ready for reeling by the end of August. The Spring cocoons go toward making the so-called Summer reeling and are the first and best of all crops. Of the Summer cocoons some go toward making Summer reelings and some to Autumn reelings. The last of the Autumn cocoons and the remnants of the old crop are used to produce the Spring reelings, and this accounts for the lower class of silk received during the months of May, June and July. Many of the filatures are closed during the winter months.

In the process of reeling, inexperienced or careless reeling girls may permit considerable waste to collect in the basins and pass up on the thread, causing a dirty thread, or allow one or more cocoons to run out and neglect to replace them promptly, causing a fine thread. On the highest grade of silk one must expect to find about one hundred defects to the pound, on the lowest grades these defects sometimes aggregate 3500 defects to the pound.

The strength of the silk thread is about three and a half times greater than cotton and three times greater than wool. The elasticity is about five and a half times greater than cotton and five times greater than wool.

PHYSICAL PROPERTIES OF RAW SILK

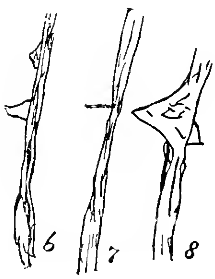
A SILK fibre, as discharged by the silkworm, consists of two fibres or cylinders of gummy material called fibroin, united together by an external layer of varnish termed sericin. The cause of this peculiar double structure is clearly seen by an examination of the method of production of the silk fibre in the body of the silkworm. By a dissection it is found that there is on each side of the body of the silkworm a set of glands, consisting of three portions; the lower portion, farthest from the mouth, has the appearance of a fine, much twisted tube, and in this the silky matter is supposed to be secreted. It is connected to a larger tube, twisted in more regular folds. This has usually a yellowish color, and is really the reservoir of the silk substance, which passes from it through a very fine tube, which again unites with a similar tube from the glands on the other side of the body to form a very minute canal, as it is termed. The silk substance has now assumed an elliptical form, and consists of two cylinders of silky matter. Whilst passing along the canal these two cylinders are united by the silk gum or varnish, which is passed into the capillary canal from two minute glands placed at the side.

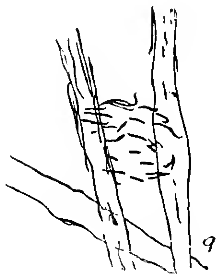
The fibrets, i. e., the two constituent cylinders comprising the silk fibres, after being thus united, pass along to the mouth of the silkworm, and out through a minute opening in the mouth termed a "spinneret," or, a "seripositor."

When the silkworm commences spinning or discharging silk fibres, the gum seems to be poured into the canal very irregularly, and the fibre appears in many respects to be imperfect; as by a microscopic examination of floss-silk fibres—or fibres which are first spun by the silkworm—large lumps of gummy matter are seen on the surface, and in some cases two fibres (each, of course, containing two fibrets) are joined together by this gummy matter. This last assumes many different forms and varies greatly in quantity. On some fibres there will be only a triangular lump at intervals—similar to fibre, Fig. 6, which is a floss fibre of the French bombyx mori. In other cases there are long lengths of gum; but if the fibre has been kept in a dry place the gum is seen to be broken into shorter lengths owing to the contraction in drying. See Fig. 3.

Fig. 9 represents two floss fibres of bombyx mori silk (Chinese) united together by a mass of gum. This explains the very impervious nature of silk cocoons, as when the fibres are placed side by side after being discharged by the silkworm, the gummy matter, which is then in a sticky and moist condition, will tend to unite them and make a solid layer of silky material.

In many cases also a microscopical examination shows that silk fibres are much expanded in some places and contracted in others, and that in other positions the two constituent fibrets are not the same size. Fibre, Fig. 5, shows a good example of the first case, and at the position where it is so much expanded the fibre seems to be structureless, and to consist of a mass of dried gum. Fibre, Fig. 4, shows the latter case, where the fibret is at intervals much larger than the other, thus causing a node on the surface of the fibre. At another position in the same fibre, the two fibrets are quite separated, and there is a space between them, as shown in fibre Fig. 1. Where a fibre has been broken, the two ends of the constituent fibret are often seen to diverge, as if the shock of breaking had loosened the gum holding them together. It is found that silk fibres appear in many positions to have been twisted around themselves; and thus





uneven planes are produced on the surfaces of the fibres. The cause of this twisting is not exactly known, but it is supposed to have been put into the silk fibres by the silkworm during the spinning operation. Silk fibres also appear to be slightly wavy, probably because the curl, which was formed when they were coiled in the cocoon, has not been removed. The previously mentioned properties, together with another, which is perhaps of greater effect than any of them, viz., their gummy nature, probably cause the great tenacity of silk yarns.

The lumps of gum on the surface of the fibres may also assist in the strengthening of yarns, but in a good silk yarn these should be absent, having been removed by the boiling-off process, which takes place preparatory to either reeling or carding. The real cause of the spinning property of silk fibres may, therefore, be ascribed to the following properties: 1, the gummy nature of the silk fibres; 2, its fineness; 3, its strength and elasticity; 4, its uneven surface produced by the twisting; 5, its length. If silk fibres are spun into yarn whilst in

a heated and dry condition—that is, when the gummy nature is partially or completely destroyed—the yarn produced is very inferior; whereas a yarn five or six counts finer can be spun in a room, the atmosphere of which is heated, but moist. The surfaces of the fibres are thus softened and rendered gummy, and the fibres cannot be drawn apart so easily; hence the yarn is stronger than that produced from similar material, but under different conditions. The moist condition of the atmosphere is also of advantage in removing the electricity which resides in the silk fibre, on account of its non-conductive nature; and it was found practically, before these properties were studied, that the very best atmosphere for the production of good silk yarns is one which is heated and moist.—Textile Record, 1895.

THE CHEMICAL NATURE OF SILK

By Thomas Wardle, F.C.S., F.G.S.

IT will add more to the interest of this subject to compare the chemical natures of both the round fibre of the Bombyx mori with the flat fibre or tussur silk. An analysis of tussur silk was made under the direction of Dr. Knecht, by E. Bastow and J. R. Appleyard, students of the chemical and dyeing department of the Bradford Technical College, in 1888, which gave the following percentage results:

Carbon	47.18
Hydrogen	6.20
Nitrogen	16.85
Oxygen	29.67
	99.90

They do not state whether the analysis was made of the tussur silk in India, Antheroea mylitta, or that of China, the Antheroea pernyi; probably it was the latter, and as they differ in structure, and, no doubt, somewhat in composition, a determination of one or the other is still to be desired, and it would be interesting to see the analyses of both side by side, and also of the gum or sericin of each species.

Let me now institute comparisons between ordinary silk and tussur silk. When the raw silk of commerce (Bombyx mori) is heated in water under pressure, it yields two compounds, fibroin and sericin, or silk gelatine. Fibroin constitutes about sixty-six per cent. of raw silk; it is a silky, glistening substance, which is insoluble in water, but dissolves in strong acids, alkalies, and a solution of cuprammonium sulphate. When boiled with dilute sulphuric acid it yields glycocol, leucine, and tyrosine. There are two analyses of the fibroin of the

silk of commerce (Bombyx mori), one by Mulder and the other by Schutzenberger, which are shown in the following table:

	Tussur silk	The ordinary silk of commerce, Bombyx mori, Calculated for Mulder's formula $C_{15}H_{23}N_5O_6$	Calculated for Schutzenberger's formula $C_{71}H_{107}N_{24}O_{26}$
	Per cent	Per cent	Per cent
Carbon	47.18	47.78	50.26
Hydrogen	6.30	6.23	6.31
Nitrogen	16.85	18.90	19.84
Oxygen	29.67	26.04	23.60

The difference, therefore, between the composition of ordinary silk and tussur silk is as follows: Tussur silk contains less carbon, according to Schutzenberger's percentage, which is 50.26; Mulder's percentage gives 47.78. Hydrogen is about the same in both silks; two to three per cent less nitrogen and about

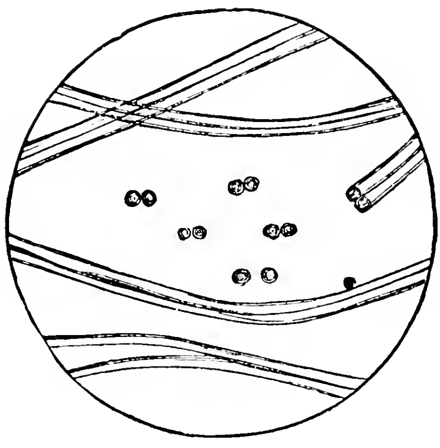


Fig. 10
ORDINARY SILK SHOWING TRANSVERSE SECTIONS

four to six per cent more oxygen. I do not consider this difference of composition sufficient to account for the difference in the dye-absorbing qualities of the two silks, which I think depends much more upon their different physical structure, and the chemical nature of the brown coloring matter of tussur silk, not yet ascertained.

Besides this, there is the difference in the amount and nature of the gummy and gelatinous envelope secreted by the respective caterpillars around the fibre

at the time of seriposition. In the Bombyx mori silk, the gum, or—as the French call it—gres, which incases the fibre as a varnish to preserve and protect it, amounts to twenty-five per cent and upward in the case of China silk, and varies in other silks from twenty-two per cent to thirty per cent, Bengal silk containing the largest amount. The foregoing analysis of its tussur-fibroin shows its nature. The composition of its gum or sericin has not yet been ascertained. From long experience of it I am convinced that it differs in constitution from that of the Bombyx mori, and there is a difference also in the sericin of the two tussur silks. It is much more soluble in hot water than Bombyx mori sericin, but it was best removed from the fibre by a boiling soap bath. Chinese tussur silk contains more sericin than Indian tussur, and it is generally loaded with saline and dirty extraneous matter. Indian tussur is always cleaner, and contains a higher percentage of silk.

The following table shows the reduction of weight of one pound each on China and Indian tussur silks as compared with the quantities respectively of four kinds of the ordinary silks of commerce—Italian, China, Japan and Bengal. This is from a recent careful examination made by one of my sons for this paper:

Species of Silk	Weight of 1 lb. after washing in water at 125° F.	Percentage of loss	Weight of 1 lb. after boiling in a bath of soap	Percentage of loss
China tussur	15 oz. 11 drms.	13.7	12 oz. 11 drms.	21
Indian tussur	14 oz. 9½ drms.	9	14 oz. 5 drms.	11
China	15 oz. 9½ drms.	2½	11 oz. 6 drms.	27
Japan	14 oz. 11½ drms.	8	11 oz. 2 drms.	30
Italian	15 oz. 5¾ drms.	4	11 oz. 8 drms.	28
Bengal	14 oz. 14¾ drms.	6¾	11 oz. 3 drms.	30

	Mulder	Schutzenberger
Carbon	15	71
Hydrogen	23	107
Nitrogen	5	24
Oxygen	6	25

Sericin or silk gelatine has a composition of $C_{15}H_{25}N_5O_8$. It is a substance resembling gelatine. Its hot aqueous solution is precipitated by alcohol, and, after drying, the precipitate forms a colorless powder, which in cold water swells

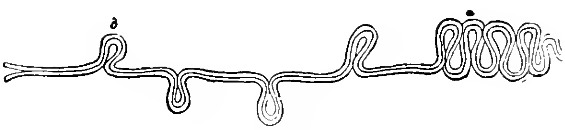


Fig. 11—TUSSUR SILK
The loops at (b) are formed by the action of the gum.

up to a gelatinous mass. On boiling it with dilute sulphuric acid it yields a small quantity of leucine, and larger quantities of tyrosine and serine, or amido-glyceric acid.

Thus the silk of the Bombyx mori consists of two distinct compounds, the pure fibre, which is fibroin insoluble in water or soap, and sericin or silk gelatine, which is the gum or gelatinous envelope or varnish of the fibre. It is partially soluble in water, and entirely dissolves and separates from the fibre in a

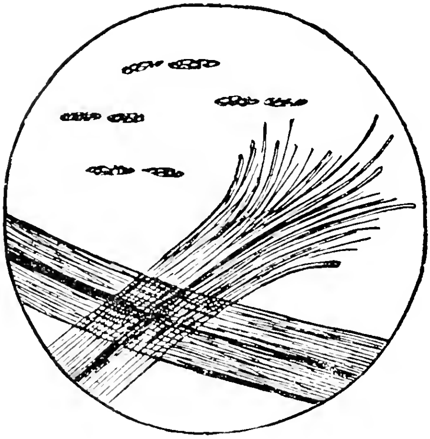


Fig. 12
TUSSUR SILK SHOWING SEPARATED FIBRILLAE AND TRANSVERSE SECTIONS.

boiling soap bath. Tussur silk has also this dual composition. The following comparative table shows that tussur silk is composed of the same elements as the silk of commerce, but in other proportions.

The soap, etc., in the manufactured thread must be considered, as the loss is not all natural.

Peroxide of hydrogen reduces a large portion of the brown coloring matter of the tussur silk, but causes a further loss of ten per cent. The gelatinous varnish of tussur silk is undoubtedly much more soluble in water than that of ordinary silk, and a few applications of boiling water will remove it altogether. I hope shortly to examine the chemical nature of the sericin of both the tussur species.

Bastow and Appelyard found a total loss of 26.49 in boiling tussur silk with water, and afterward with soap solution. This rather points to the silk they examined being a sample of Chinese tussur, and loaded with its usual extraneous matters. I frequently find a still higher percentage of loss in Chinese tussur, occasionally as high as forty-five per cent. The specific gravity they state to

be 1.440. They found a high percentage of ash in raw tussur, consisting of inorganic substances in the following proportions:

	Per cent
Soda (Na_2O)	12.45
Potash ($_2O$)	31.68
Alumina (Al_2O_3)	1.46
Lime (CaO)	13.32
Magnesia (MgO)	2.56
Phosphoric acid (P_2O_5)	6.90
Carbonic acid (CO_2)	11.14
Silica (SiO_2)	9.79
Hydrochloric acid (Cl)	2.89
Sulphuric acid (SO_2)	8.16
	100.35
Oxygen equivalent to Cl	0.65
Total	99.70

FROM A LECTURE BY PROF. WATSON SMITH, ENGLAND*

Of the animal fibres silk is one of the most perfect substances for use in the textile arts. A silk fibre may be considered as a kind of rod of solidified flexible gum secreted in and excluded from glands placed on the side of the body of the silkworm. The fibre is semi-transparent, but the beautiful pearly lustre is due to the smoothness of the outer layer and its reflection of the light.

In the silk fibre there are two distinct parts: Firstly the central portion or, as we may regard it, the true fibre chemically called fibroin; and secondly, an envelope compound of a substance chemically called sericin and often called silk glue or silk gum. Both it and fibroin are composed of carbon and hydrogen, nitrogen and oxygen. Hence here we observe one element more than in the vegetable fibres referred to, namely, nitrogen; and this nitrogen is contained in all the animal fibres. Sericin can be removed by warm or hot water with a little soap. Warm dilute (that is weak) acids such as sulphuric acid, etc., also dissolve this silk glue, and can be used like soap solution for ungumming silk. Diluted nitric acid only slightly attacks silk and colors it yellow; it would not so color vegetable fibre, and this forms a good test to distinguish silk from a vegetable fibre. Cold strong, acetic acid, that called glacial acid, removes the yellowish coloring matter from raw silk without dissolving the sericin. By heating under pressure with acetic acid, silk is quite dissolved.

Silk is also quite dissolved by strong sulphuric acid, forming a brown thick liquid. If we add water, a clear solution is obtained, and then on adding tannic acid the fibroin is precipitated. Strong casutic potash or soda dissolves silk, more easily if warm. Diluted caustic alkalies will dissolve off

*Published in the American Silk Journal.

the sericin and leave the inner fibre of fibroin, but they are not so good for ungumming silk as soap solutions are, as the fibre after treatment with them loses whiteness and brilliancy. Silk dissolves completely in hot basic zinc chloride, and also in alkaline solution of copper and glycerine which does not dissolve vegetable fibres or wool.

A STUDY OF THE PHYSICAL PROPERTIES OF SILK

By Dr. K. Hagihara*

Structure of the Cocoon Thread

As is already known, the cocoon thread is composed of two silk fibres or so-called baves united by a gelatinous substance. The former is called fibroin and the latter sericin. The fibroin is the bright fibre with a white, yellow or green shade, and its sectional form is generally a curved triangular section with rounded corners, but we can occasionally find the round or elliptical sections, and sometimes the oblong or irregular sections. The form of the section varies according to the conditions of drying the fibroin; when the cocoon dries gradually, the too much crushed or deformed parts will have oblong or irregular sections; the parts where the deformation takes place at its sides will have rounded triangular sections, and the parts where the fibres are freely suspended in the cocoon will have round or elliptical sections. The deformed section gives the thread a rough touch and tears very easily by rubbing, and the regular section gives the thread a smooth and supple touch, a brilliant lustre and much more resistance against rubbing.

Now, the fibroin is composed of numerous silk fibrillae running in the axial direction of the thread and parallel to each other. If we examine the silk thread under an ultra-microscope, we can easily see the numerous bright and dark lines running in an axial and parallel direction. The fibroin, thus constructed, becomes more flexible and stronger than a solid or a single fibre of the same size, owing to the regularly cemented bundle of numerous fibrillae. On the contrary, the sericin is composed of an aggregation of grains and is very amorphous, as in the case of ordinary gelatinous substance. Thus, serving as a uniting or dressing material only, the sericin is not so strong as the fibroin, but brittle against pulling and gives a hard touch to the fibroin. Therefore, if the thread be uniformly surrounded with a large quantity of sericin, the thread will be very stiff and more elastic, but not ductile. If the quantity of the sericin be small, the thread will be very soft and less elastic and will elongate too much. If the thread be unevenly coated, the touch will be too rough, the evenly coated thread being very smooth and lustrous. If we want a thread of harsh touch it is essential that the sericin should surround it very evenly and its quantity should be large enough to coat the fibres.

As the sericin has a granular structure like sandstone, it is the author's opinion that it has the capacity to absorb more moisture than the fibroin and tenders the fibroin when elongated under tensile force. Like the sized cotton thread, when the thread with sericin is strained by tensile force, the sericin

*Copied from "SILK" by permission of Dr. Hagihara.

will protect the fibroin against external force and give it strength. But the sericin, being too weak against the pulling force, breaks first into fragments and the fibroin with cracked sericin is strained. The cracked sericin, having more exposed surface than before to absorb the moisture, is dissolved a little by atmospheric moisture and improves the coating condition and makes the fibroin elongate more than it otherwise would. This phenomenon takes place when the quantity of sericin is small or the fibroin is surrounded with a very thin coating of sericin. As regards the quantity of sericin, the rough measurement can be easily made by comparing the scouring loss of sericin at the testing of boiling-off.

It is the usual practice to denote the size of the thread by weight and length. For silk fibre we use the same principle to measure the size of the fibroin, taking 450 meters as standard length and 0,05 grammes as standard weight. But the silk fibres, having a definite source called "cocoon" to make a yarn, cannot build up a "roving" of required weight per unit length by drawing the aggregated fibres as the cotton and other fibres do in the spinning process. As this source of fibres supplies only a fibre of definite size and length, the size and length of a single fibre cannot alter at will. From this fact the size of the thread is measured by the weight corresponding to the standard length reduced to the standard weight, assuming that the specific gravity and area of the fibre are always constant. So, the heavier the thread weighs, the thicker the size of the thread becomes. The approximate size is thus measured, but it is very difficult to measure the precise size, especially the diameter of the fibroin. As we have stated before, the form of the fibroin is not a circular section and therefore it is rather preferable to measure the area of the section instead of the diameter, by means of micro-photographs. Table No. 1 shows the areas of the different species of various origins. The first column of area expresses the area of fibroin at 300 meters from the beginning of the cocoon and the next column at 400 meters. When the length of the fibroin is under 600 meters we have measured the area at 200 and 300 meters from the beginning.

From this table and the accompanying photographs (Fig. 13), we can see that the area of the fibroin is not constant and has a tendency to diminish gradually. If we measure the areas at each twenty-five meters from the beginning to the end of the cocoon, we find that the area of the fibroin increases up to 200 or 300 meters and then decreases to 500 or 600 meters, and then there are two kinds of cocoons which decrease the area suddenly or diminish gradually. It will be interesting to compare the area and the corresponding weight at each twenty-five meters, and the accompanying table No. 2 shows the variations of area and weight of three different cocoons. From this table we can find that the weight and area are not proportional, that is, the area varies independently as the weight varies. It is not clear why this ambiguity exists. If specific gravity be constant, the increase of area against weight will show that it is enlarged by invisible pores of a large number, and the decrease of area against the weight will show that the fibroin is delivered in a very compact condition from the mouth of the worm. From these results we may

say that it is not possible to determine the size for scientific research by measuring the diameter or the area of the section, and that it is rather preferable to determine the "effective area of the section" by measuring the weight and specific volume of the fibre.

TABLE No. 1

Areas of Cocoons at 300 and 400 Meters

Kinds of Cocoon	Area of 300 M	Section at 400 M
Italian O	1.10	1.05
Hakuriu	1.25	0.95
Nihon Nishiki	1.05	1.00
Cho Hakuriu	1.55	1.15
Yamato Nishiki	1.25	1.10
Nihon Nishiki X	1.25	0.65
Hakuriu X	1.28	1.30
Nihon Nishiki Yamato Nishiki X	1.30	0.95
Matamukashi	1.30	0.95
Hakuwiu X	1.28	1.30
Seihaku Yamato Nishiki X	1.20	1.13
Italian B	....	....

N. B.—To find the actual area in square millimeters, multiply the number in the table by 0.000325.

Structure of the Raw Silk Thread

After the cocoons are soaked in boiling water, the several fibres coming from them are united in a little hole of porcelain instead of being brought together by hand. This hole is pierced in the centre of a porcelain button above the basin and prevents cocoons jumping after the thread. Then the united fibres, becoming now a thread, are twisted together on each other. By this operation the fibres are made regular, well aggregated, perfectly cylindrical, and cleaned of gross irregularities. This twist serves also to extract the water in the fibres by quick turning and wringing. Then the thread is passed over the hooks and is wound on a reel, which is driven in a closed dry casing to dry the silk and to prevent the gums of the fibres from sticking together.

According to the required size of the thread and the size of the cocoon fibres, a silk thread is composed of several fibres united by their own sericins. The fibres should be aggregated in a round form, and each fibre should be evenly stretched in a straight condition. In order to stretch the fibres evenly and to wring out the surplus water, twisting is applied. For this twisting there are two systems in practice: One of them is called "Chambon" system, by which the two adjacent threads are coupled and twisted together. The other one is called the "Tavelette" system, by which the twisting is done with its own thread, that is, it goes directly from the glass ring or button to a small wheel and runs back to another wheel below, and goes up again, twisting

TABLE No. 2

Area and Weight at Different Length of Cocoon Threads for European, Chinese and Japanese Silks

Japanese Silk "Hakurin"			Chinese Silk "Kinko"			European Silk "Rogo" White		
Length	Weight	Area	Length	Weight	Area	Length	Weight	Area
120M	11,400	2,100	120M	9,900	1,618	120M	12,726	1,940
140	11,200	2,100	140	10,500	2,112	140	12,853	1,863
160	12,000	2,217	160	10,700	1,758	160	13,150	1,870
180	14,000	2,113	180	11,400	1,793	180	13,362	2,013
220	12,300	2,239	220	11,500	1,978	220	13,574	2,105
240	10,750	2,100	240	11,000	1,827	240	13,233	1,991
290	11,000	2,000	260	9,000	1,930	260	12,938	1,925
320	11,900	2,074	280	10,700	2,040	280	12,514	1,950
340	12,500	1,975	310	10,200	1,875	320	12,302	2,018
390	10,100	1,857	330	9,750	2,053	340	12,514	2,025
420	10,000	1,810	360	10,400	1,850	360	12,726	1,950
460	9,900	1,790	380	9,500	1,690	380	11,665	1,950
480	8,300	1,800	440	10,700	1,637	420	12,302	1,793
540	8,500	1,650	460	9,800	1,967	440	12,089	1,780
560	10,300	1,820	480	10,500	1,572	460	11,654	1,746
620	6,500	915	510	10,700	1,717	480	11,750	1,755
			530	12,200	2,024	520	10,817	1,713
			560	10,200	1,693	540	10,131	1,590
			580	8,500	.....	560	9,799	1,603
			610	9,250	1,530	580	8,908	1,538
			630	10,200	1,275	620	9,375	1,530
			660	10,400	1,450	640	8,314	1,320
			680	9,200	1,375	660	7,975	1,260
			700	8,100	1,103	680	7,678	1,250

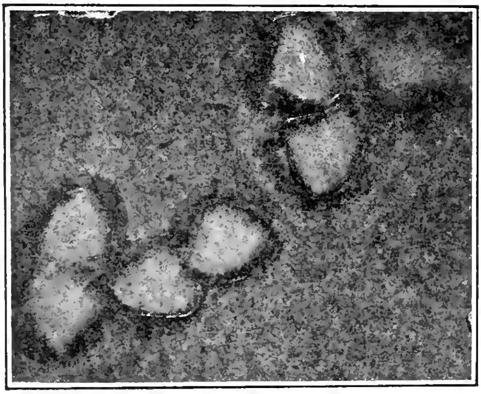
N. B.—To find the actual weight in grs., multiply the number in the column of weight by 0,000012394 and for area in qmm., multiply the number in the table by 0,000649.

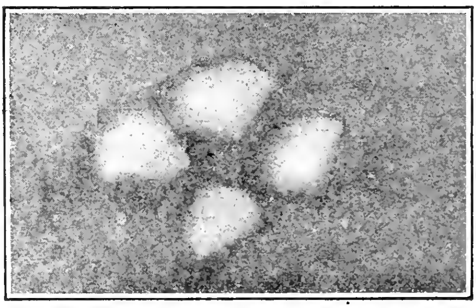
itself and running to a third wheel and then directly onto the traveler over a horizontally moving hook which regulates the distribution of the thread on the traveler or cross reeling. If the fibre comes very easily, it is not necessary to soak the cocoons in boiling water too long, but if the fibres are difficult to reel the cocoons should be soaked for a long time to loosen the sericin. Too long soaking of the cocoons makes the thread too weak, less elastic and the fibres are coated with very thin sericin.

As the silk thread is drawn out through the twisting, it has a tendency to become flat, or if the thread be treated by improper twisting, the fibres composing the thread are arranged in flat condition like a ribbon; if the thread be treated by proper twisting it will be round and smooth. It is an

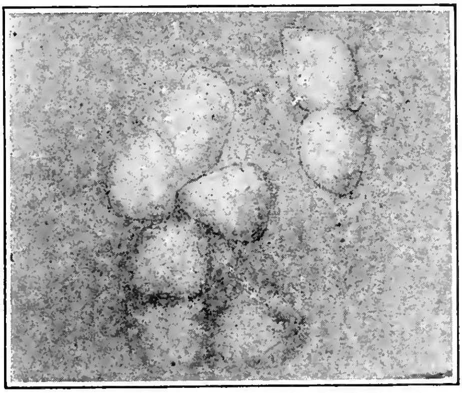
essential condition that the thread be composed of evenly stretched and round fibres; a flat thread causes fluffy or fuzzy yarn owing to the rubbing action during the scouring and the weaving process.

Fig. 13
SOME EXAMPLES OF SECTIONAL FORMS OF THE FIBROIN OR COCOON FIBRE. MAGNIFIED 800 TIMES.





As regards the sericin, the reeling process gives the sericin a great influence upon the uniting and coating actions. Too much twisting lessens the sericin or sticks a large lump of sericin to the thread, and too slight twisting makes the fibres too free and flat and lessens the coating effect of the sericin on account of the aggregation of wavy fibres. Improper soaking makes the cocoons too hard and difficult to reel, and we get a thread with knots, nibs and loops. With insufficient soaking we get a thread of dull color and with sufficient soaking a thread of bright color. Besides these processes the thread is affected by the quality of cocoon used and the degrees of the steaming and drying process for the cocoons.



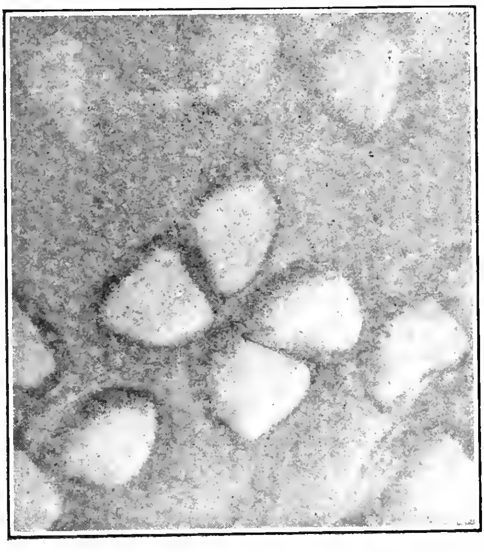


Fig. 13
SOME EXAMPLES OF SECTIONAL FORMS OF THE FIBROIN OR COCOON FIBRE. MAGNIFIED 800 TIMES.

Size of Raw Silk and Its Diameter

As stated before, the cocoon, the source of the fibres, has a definite length and size; consequently, the size of the raw silk depends upon the size and number of cocoons. The size of the silk thread is approximately equal to the number of cocoons multiplied by the mean size of the cocoon fibres or equal to the sum of the size of each cocoon thread applied. It is evident that the thread should be strong and flexible if it be composed of numerous fine fibres united together in round form. To get the thread with a number of fine fibres there will be some practical difficulties such as the breakage of fibres, but we can get a thread of comparatively even size by applying a number of fine fibres. However, the cocoon fibres are not uniform in size and the denier which expresses the size is only the mean size of said fibres 450 meters long, and cannot apply throughout the length, especially for short length fibres. Consequently, it is impossible to get perfectly uniform silk thread by composing such irregular cocoon fibres. For this reason, the author has made a micro-balance of glass thread to measure the minute length of the silk thread which is applied to the testing machine in order to get exact and fine results. This balance is capable of measuring about one thousandth of a milligramme and is used to measure the weight of test pieces of short length. The author has endeavored to measure the effective area of a section of a test piece in order to calculate the actual size, the actual stress and elasticity of silk, but it was in vain on account of the uneven size or the irregular form of the thread. Consequently, the author has decided to express the size of the silk by weight and specific gravity, for which we have built a special machine to measure the volume of silk thread on the principle of Dalton's Law. And, as we cannot measure the absolute value of different qualities because of this objection, we will discuss the silk thread by measuring the relative values for different qualities and will express these values by the numerical coefficient by dividing by the weight of the test piece or reducing to unit weight of the tested thread.

PART I—CHAPTER II

RAW SILK PROPERTIES AND DEFECTS DEFINED

The principal qualities of raw silk are:

Color	Nature	Cleanness
Lustre	Cohesion	Evenness
Hand	Strength	Ductility

Color

Color may be classed as yellow, white, ivory, and cream, even or uneven in shade. True, there are many other shades, but these will serve all needful purposes. The temperature and cleanness of the water in the basins has frequently much to do with the color.

The importance of color is found when dyeing into the lighter shades.

Lustre

Lustre indicates the bloom of a nervy, healthy thread, yet it is not always true to this condition, and it may be produced in reeling the cocoons. This quality also can be artificially produced in dyeing.

It has been said that since the dyer has within his power the lustering of silk that this quality need not be considered, yet we must remember that the dyer, even though skillful in the art, cannot get the same lustre from a silk low as from one high in its physical qualities. The twist and soaking also changes the lustre so that very little can be said of this quality from a visual inspection, when thrown into organzine or tram.

Paul Francezon in "Studies on Silk Reeling" says; "I have reeled for several years special silk, in water saturated with the salts of the chrysalis and silk gum. It has never been renewed. When filtered, it came out a deep yellow and has a strong acid reaction. The silk was dull and grayish in color. After degumming it was as brilliant as the others; all foreign matter had disappeared and it had a maximum porosity. The yield with this water was almost the same as when I reeled with ordinary water.

"That proves how little the search for brilliancy in silk is justified; for my part, I find it deplorable, for it is impossible to obtain it except by renewing the water frequently and above all by lowering the temperature, two conditions absolutely incompatible with obtaining strong silk.

"To sum up, distilled water allows reelers having only lime and alkaline water at their disposal to make excellent silk, when without it all their efforts would have been useless."

A silk high in cohesion is always high in lustre, but a strict relation does not exist between cohesion and lustre, as a thread may be low in cohesion, due to the lack of twist in reeling the cocoon, but a silk low in strength and cohesion is always deficient in lustre. A silk high in lustre also possesses good filling properties.

Hand

The hand of raw silk may be classed as silky, nervy, spongy and strawy. It is that quality of a silk fabric that prevents it wrinkling and may be called resiliency.

I have made an attempt to measure the resiliency, but as yet developed no definite method and depend on the sense of touch to judge the quality. Ordinarily the hand of a fabric can be supplied in dyeing and finishing, but when an extra good hand is desired the raw silk must be carefully selected.

Dr. Hagihara says: "Filling is a property which makes the goods voluminous and may also be called 'fullness of the hand' or simply the 'hand.'

"If we take in hand a mass of fibres, thread or cloth, we feel it full in the hand. This feeling is caused by the filling property of the material, and we feel a goods rich when the material has this property sufficiently, and vice versa.

"This property depends on nothing else but the elasticity of silk. The elasticity of a thread, as stated before, is affected by the aggregated form and the cemented condition of the fibres besides the elasticity of the fibre itself."

Nature

The nature of the silk may be classed as hard, medium and soft. At present there appears to be no definite knowledge of this quality; also there is a great variance of opinion as to its importance.

We find in Japan silks a hard, soft and medium nature. The hard natures have a hard, dense thread and are strong. They offer great resistance to ungumming in the process of dyeing.

I. Honda, director of the Tokio Sericultural Institute, says:

"A few years ago a good hard silk was manufactured in the district of Kai, but now it has no such peculiar character, because there the silk is made of material mixed with cocoons raised in the other districts. The cocoons raised in the colder districts, such as the districts of Yamagate in our country, have a harder nature than those of the other place."

Dr. August Hunziker in his report on skein dyeing in March, 1912, says that "an every day occurrence with the dyer, unfortunately, is the trouble experienced with soft natured and lousy silk. Would it not be possible for a manufacturer when selecting the qualities of silk for special purposes, to be guided by the fact that soft natured silks should not be used for the highly lustred goods so much in vogue now, as the hairiness and lousiness will show much more in a lustred than in a regular dye. Souples or lightly weighted blacks would not show these defects. For highly lustred goods it is absolutely necessary to use the best grades of silk, reeled as evenly as possible."

Ravelings of Dyed Silk by the director of the Silk Conditioning House of Milan, page 38, says:

"Even when the manufacturer has a clear idea of all the factors that have an influence on the lustre of the fabric and has regulated the purchase of silk in relation to them, the result is always subordinate to the work of the dyer, who in his turn has difficulties to overcome in order that—especially following the boiling off—that silk may keep its lustre unaltered. If the threads were always of the same nature, it ought not to be difficult to settle the conditions under which the ungumming may be accomplished without inducing splitting, but as they differ in the breed of the worms, the size, the degree of twisting, the manner of winding and stretching, the work of the dyer becomes very difficult. Having to dye for third parties, he has no way to find out the source and the age of the silk entrusted to him. Even if it were his duty to make opportune tests in advance of boiling off in order to recognize the nature of the silk, and to classify it with the purpose of timely modifying of the boiling off process according to the quality of the silk, he generally studies only the organopleptic characteristics, which are uncertain and cannot always be assisted by the customary tests as these concern the thread and not the original fibre by which the former is made.

"Even if the dyer were aware of the quality of the silk which he receives daily from the manufacturers, it would not be possible for him to take into consideration all the factors that have an influence on the result of the boiling off; not only because it is not easy to establish their entity but also because the compensation he receives for the ungumming and dyeing does not allow him always to keep separate the different parcels and to proportionate the duration of the boiling off in soap bath with the nature of the thread."

Page 42, under conclusion, reads:

"That dyers have a task to adjust to the changeable resistance of the fibre treatments to which the latter must be subjected in order to be ungummed and dyed."

It is well known among practical throwsters that hard natured silks are far more buoyant in the soak tub than soft natured.

From the above facts the following conclusions are drawn:

1st—It would appear that hard natured silks are made such by the nature of the sericin causing the fibres to unite more firmly and resisting the action of the soapy liquor to a greater extent than a soft natured gum.

2nd—If a hard nature resists the action of the soapy liquor longer than a soft nature it would appear logical to conclude that by using a standard soap solution and temperature the time in which a skein of silk becomes saturated would indicate a unit showing the various natures of silk.

In dyeing, the buoyancy of the silk is considered as an indication of its nature.

I have just been informed by a reliable authority that hard nature was largely caused in the drying and stifling of cocoons, and this may be explained as pos-

sibly due to the fact that the sericin when baked on freshly spun cocoons becomes tougher, the same result as is experienced in baking varnish.

Professor Gianoli says:

"It is generally admitted that not only notable differences in the composition of the fibroin exist in the silk from different districts, but that a varying action is exhibited toward acid and alkaline solutions."

Cohesion

Cohesion is the term first applied by Rosenzweig in Serivalor to the force that causes the two cocoon filaments to stick together as one compact thread. In physics, cohesion is considered as the mutual attraction of the particles of a solid for one another, and is measured by the amount of force which must be applied in order to overcome it. The term cohesion is generally applied to the mutual attraction of particles of the same substance; adhesion to that of different substances.

The silken fibre (sericin and fibroin) consists of two filaments which when issued by the worm through its spinneret are laid side by side and agglutinated together as one cocoon fibre. The force of this agglutination we call cohesion. The threads that are agglutinated very tightly are dense and firm and resist opening a long time; these we call a very good cohesion; those that are loosely agglutinated and open very readily we call very poor cohesion.

The fact that the cocoon fibres consist of two filaments enables us to measure the cohesion of the cocoon fibre, but as we use only the reeled thread we are not interested commercially in the cohesion of the cocoon fibre except as it relates to that of the reeled thread and its relative value in classifying the physical qualities of raw silk.

My experiments on raw silk thread reeled with a long, medium and short croisure or twist indicate that cohesion is dependent on the cohesiveness of the sericin, the length of the twist in reeling, and temperature of the water.

Further observations show first, the importance of having cocoons uniform in quality; second, that lustre is corelated to cohesion; third, that ninety per cent of tests show tenacity and cohesion practically alike in their relative value.

All reelers agree that to produce a thread with a high cohesion requires a high grade seed, close attention in sericulture, careful and skilled reeling. It will be observed that since the requirements of a thread with a high cohesion enhance its value, if in the classification of raw silk we base its physical qualities on cohesion, then we have a basis that presents a relation true to its real cost to produce and is therefore worthy of serious consideration.

In weaving single thread in the gum the cocoon fibres constituting the thread must be well agglutinated; if one or more fibres are loosely gummed together then when the threads rub against each other as the shed opens and closes or the harness or reed rubs the thread, then these loosely agglutinated threads open, split off one or more fibres and frequently break.

In skein dye we find that silk with a very poor cohesion has a tendency to split up in dyeing and cause lousiness, also that when the sericin is boiled off

it produces a skein very wavy or exceedingly loopy in appearance. In spinning organzine with a thread of low cohesion sometimes one or more cocoon fibres split off, run a band on bobbin, cause excessive breaks, labor cost and waste.

In knitting single thread in the gum a thread must have sufficient cohesion to stand a heavy soaking and not open up the fibres, as an open fibre catches in the knitting needles and causes defective fabric.

Prof. K. Hagihara says that the cementing material, or sericin, has strength against compression or crushing force, thus serving to protect the fibroin against external pressure, and that this protecting action of the sericin depends upon its quality and coating condition.

Chief Inspector Hosokawa in his articles appearing in "SILK" during 1921 shows that a silk cannot be an Ex. Ex. unless it has a good cohesion.

Low cohesion undoubtedly indicates careless or improper reeling methods, or low grade cocoons, therefore, a silk low in cohesion cannot be a high grade silk.

Mr. Rosenzweig, in the American Silk Journal, December, 1915, says that water used in reeling has a decisive influence on the cohesion; the nature of the sericin and the twist the silk receives are the important factors in cohesion; that loops and an intermediate form between loops or the so-called "rognose" (scabious) frequently called corkscrewed threads, also influence cohesion."

F. A. Vivanti, in his report to the Silk Association of America, in 1900, says:

"The greatest of all faults has generally been described by throwsters or manufacturers as **'Double and Split Ends, Fine Ends, Fuzziness and Brittle Threads,'** and the writer is convinced that all arise from one and the same cause; now there are many peculiar circumstances connected with lots that were thus described which have attracted the writer's attention, and which have induced him to make numerous investigations. The conclusions drawn by him are as follows:

"True Double Ends, or the complete and fully formed thread running double in the skein (a fault caused by the reeler's carelessly attaching two complete threads to one and the same skein on the swift, instead of to two separate skeins, as she should) have certainly been found to exist at times, but not nearly so often as throwsters have claimed and have believed was the case; in most instances what were taken for **Double Ends** were really **Split Ends,** i. e., the one original thread had 'disintegrated in the soaking and had divided itself into two or more threads;' plainly speaking, the soaking had dissolved the gum, and the original five or six threads of the cocoons which had gone to make up the one thread of raw, had again been divided up into two or more parts, the natural gum no longer holding them together.

"This, therefore, is the really dangerous and important defect which has given so much trouble this season, and has so generally lowered the reputation of Japan silks.

"Numerous minute and careful examinations have convinced the writer that in every case where these split ends existed, together with other defects usually accompanying them, these split ends and accompanying defects were only dis-

coverable after the raws had been soaked for throwing and not before, and this in spite of every winding and conditioning house test.

"It is needless to add that this impossibility of discovering this great defect in the unsoaked raw is precisely what renders it the most dangerous and insidious drawback that silk can have. The very silk which, after being soaked, discloses split ends and a fuzziness and brittleness which makes it extremely difficult to work, will generally in its unsoaked state stand the strictest and severest winding tests which an inspector or a public conditioning house can subject it to, and will show excellent results.

"The cause of the mischief is very simple and is easily located by anyone who has had a practical training in the reeling of raw silks; it lies solely in the fact that the twist which the reeler should give to the raw thread around itself in the process of reeling is made far too short (see Fig. 14). This twist is the process that thoroughly compresses, kneads and welds together the five or six threads of the cocoons and forms of them one thread; it takes place when the natural gum is partly dissolved and the threads are all wet, and it is only when this twist is long enough that the single raw thread will afterwards resist sufficiently the disintegrating effects of soaking before throwing. This twist should be from two to four inches long in order thoroughly to weld the cocoon ends together; when less than two inches long it is almost certain that the quality of the raw produced will prove poor **after soaking**; the longer the twist the better and more compact and clean the thread becomes; the shorter the twist, the more, after soaking, will the thread become fluffy, loose and liable to split.

"The longer the twist, however, the greater will be the strain on the thread when the raws are being reeled and, in consequence, the slower must the swifts go around and the less silk can be produced in a given time; herein lies the whole secret; in order to hasten the production of silk and to have his swifts go round as fast as possible, the Japanese reeler has had to lessen its strain on the thread and to gain this end he has often allowed the twist to be made absurdly short. In this way he certainly has hastened the production but at the expense of a poor and imperfectly welded thread. The reeler, moreover, had so much less hesitation in yielding to this temptation because he knew that according to the customs of the trade in Yokohama, no inspector could soak the samples of any lot for winding test and that therefore the defect was sure to remain undiscovered; the tests that are now allowed by custom both in the conditioning house and to the buyer in Japan would disclose irregularity of size and most other defects, but silk reeled in the most injurious way of all, viz.: with a short twist, which would show its inferiority **only on soaking before winding** was and still is safe from detection. It is well to add that even when first-rate cocoons are used, a really good silk cannot possibly be produced with a short twist, whilst with cocoons of even only medium grade quite a good silk can be turned out, provided a good long twist is given the thread in the process of reeling. The Italian reelers fully realized this years ago and they consequently make an excellent silk of even their second and third-rate cocoons; this speaks for itself."

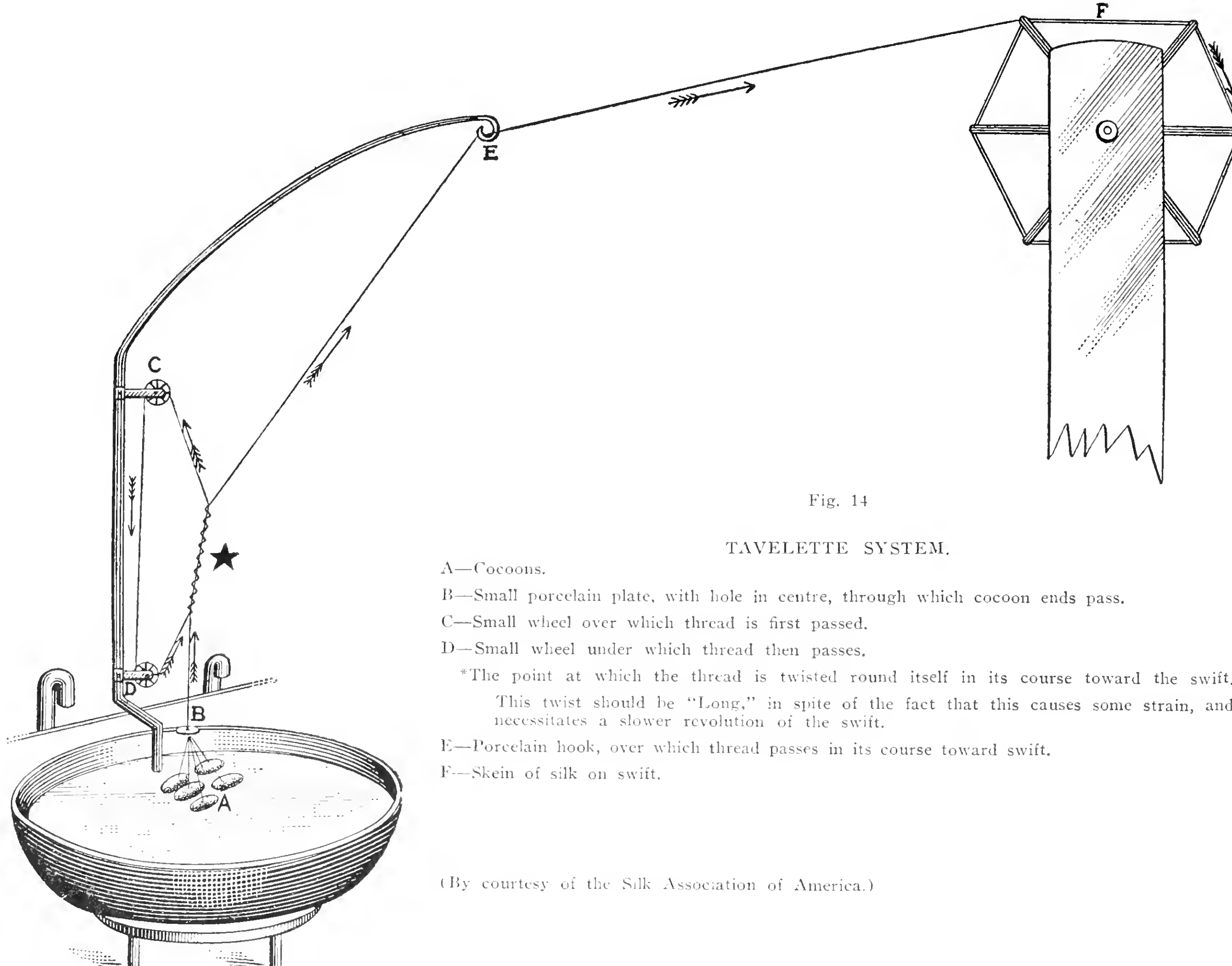


Fig. 14

TAVELETTE SYSTEM.

A—Cocoons.

B—Small porcelain plate, with hole in centre, through which cocoon ends pass.

C—Small wheel over which thread is first passed.

D—Small wheel under which thread then passes.

*The point at which the thread is twisted round itself in its course toward the swift. This twist should be "Long," in spite of the fact that this causes some strain, and necessitates a slower revolution of the swift.

E—Porcelain hook, over which thread passes in its course toward swift.

F—Skein of silk on swift.

(By courtesy of the Silk Association of America.)

Strength

Strength is the resistance of the thread to being broken apart and is measured by the force required to separate it.

The instrument generally used is the Serimeter as shown by Fig. 15; the breaking force is expressed in grams. It is intended to measure the physical character of the thread and not its structural condition.

As the strength of silk thread is in proportion to its weight, count number or denier, we cannot take a single thread and determine whether the thread is strong or weak unless we know its size.

"Let us assume that a fourteen denier thread breaking at fifty-six grams is a strong silk, a thread breaking at forty grams whilst breaking at a strain of thirty per cent less is not necessarily a tender silk as the thread tested may be only a ten denier, and in that case it would be relatively just as strong from a physical point of view even though structurally it is thirty per cent weaker than the other. In other words, the tenacity test is intended to show whether the thread is tough, hardy or tender, and from the result determine how it will act in the various processes of manufacture and what will be the character of the finished thread and cloth. The fact that a thread breaks at fifty-six grams is of no value if the size of the thread is unknown, and we must therefore consider its breaking strength in connection with its size and arrive at a relative value. Four times the average size of the silk thread has been accepted by European conditioning houses as representing strong silk and we have adopted this as representing one hundred per cent silk. Check tests in throwing and weaving confirm this finding, and it has been used as the basis of strength tables as given in Chapter VI.

*Knowledge of the defects in silk is not sufficient to form a judgment of it, as the very best appearing may work badly if it lacks tenacity and if its stretching percentage is too small; and so, after the experiments, I submit the raw silk to the serimeter, which allows me to determine with great exactness the weight in grammes supported by the thread and its stretching percentage at breaking.

It is remarkable that Japan silks, weaker than the yellow ones as to stretching per cent at breaking, should have, in all classes, a tenacity equal to that of these latter silks.

The silk reeled in pure water yielded in the mill, and later in the fabric, remarkable results, while the silk from the lime water yielded a dead fabric and was full of loops."

Prof. Hagihara says that it is reasonable to judge the quality of silk by the amount of its breaking strength, but as there are many materials of different qualities and equal breaking strength, therefore, he says, we cannot determine the quality of material by breaking strength only, and we should rather study and test the qualities of their variation within the breaking limit. He gives from an extensive series of experiments on the Serigraph (see Fig. 84, Part IV) the Coefficient of Elasticity, Cohesion of Fibroin and Sericin, Hardening, Deteriorating and Filling, or the special properties and weaving qualities desired of silk. He shows conclusively, other things being equal, that a well rounded thread,

*Extracts from Serimetric Experiments by Paul Francezon.

evenly doubled and well cemented, possesses the highest coefficients of all qualities, and such a thread I also find has the highest strength and cohesion values or possesses the highest physical qualities.

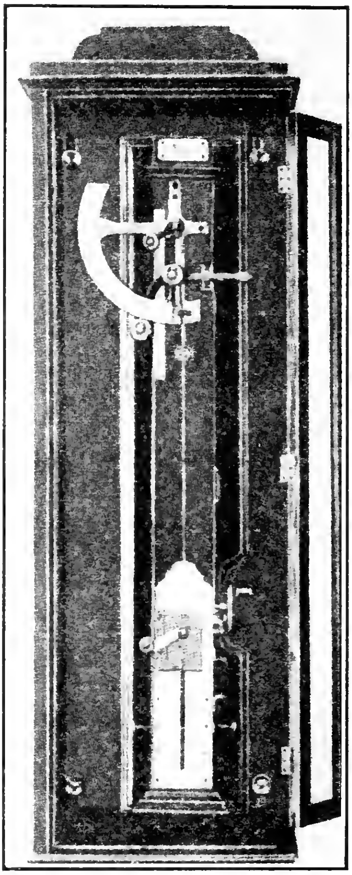


Fig. 15—SERIMETER OR STRENGTH AND DUCTILITY TESTER.

Ductility

Ductility, more frequently called elasticity, is measured on the Serimeter and consists of the increased length of the thread when stretched to its breaking point, and expressed by percentage compared with its original length. I find this quality essential to good working qualities in throwing and weaving.

A thread of glass of the same diameter as silk, while its tensile strength and cohesion are much greater than silk, because of its brittleness or lack of ductility and pliability, will snap off under the slightest strain.

A humid atmosphere, soaking or spraying with oil, makes the silk ductile and pliable. In winding under a dry atmosphere when the thread catches in the skein it snaps off, but the same thread under a humid condition stretches out, releases the tension, and often pulls through without a break. In weaving, when a coarse thread or defect strikes the heddles or reed, under a brittle condition it breaks out, but when ductile it stretches out, releases the tension and may pass through without a break.

As all silks are ductile in a humid atmosphere, and even the poor grades, in respect to this quality, always have more than a sufficient amount to meet every requirement, it appears that this quality need not be measured or considered in the classification of raw silk. At least I cannot find any relation between any quality of the fabric and this test on the Serimeter.

Paul Francezon says: "It is remarkable that Japan silks, weaker than the yellow ones as to stretching per cent at breaking, should have, in all classes, a tenacity equal to that of these latter; the stretching percentage at breaking is called 'Elasticity'; the term is inaccurate, as the silk is very slightly elastic in the true sense of the word, and I do not use it.

"We may admit as sufficiently accurate the fact that one per cent of water, more or less, increases the stretching per cent of ten millimeters within the range of eight to eleven per cent; beyond this limit the rule is no longer exact.

"We may conclude, from the results given in the principal tables, that the stretching per cent of extra Japan raw varies from 200 to 210 millimeters and that of Cevennes Yellow extra from 230 to 245 millimeters; it is to these typical results that we can refer those of other silks, in order to judge them; remembering that from 150 to 211 millimeters would indicate very ordinary silk."

Dr. Hagihara calls this quality the elongation of the silk thread. He says it is reasonable to judge the quality of the silk by the amount of its breaking strength, but we cannot agree to judge the silk quality by the amount of its breaking elongation.

As we cannot use the thread at the breaking point in weaving, we should use the thread stretched within the breaking limit to promote the efficiency of the machinery used, and to improve the quality of the cloth.

Therefore, we cannot determine the quality of material by the breaking strength only, and we should rather study and test the qualities and their variations within the breaking limit. For this purpose Dr. K. Hagihara invented a testing machine with an automatic recorder called a Serigraph, as shown by Fig. 84, Part IV.

Dr. Hagihara finds that the elongation of a silk thread consists of three elongations, i. e., the elongation of the fibre itself, surplus due to irregular doubling, and the atmospheric effect.

Elasticity is the power which a body possesses of returning to its original shape and dimensions after the forces which have been applied to it are removed.

A material is said to be perfectly plastic when no strain disappears when it is relieved from stress.

In a material like silk thread we can find very slight permanent extension at the first instance of loading.

This permanent extension continues to grow at slight increasing rate as the load increases and at the bending point of the curve, which corresponds to the yield point of the material, becomes many times greater than previously. After this point the permanent extension increases at an accelerating rate with greater loads. On the other hand the elastic extension, which is an extension to spring back or disappear when the stress is removed, exists together with the permanent extension till the thread breaks.

We will call this permanent extension a plastic elongation and the elastic extension an elastic elongation. This elasticity cannot be measured on the Serimeter, as it is not the per cent of stretch at the breaking point as commonly made on the Serimeter, but is determined by a test made on the Serigraph invented by Dr. Hagihara. He says further: "As regards the elasticity of the fibre, there is no means directly to measure it from the load strain diagram of a given thread."

As the filling coefficient is dependent on the elasticity of the fibre and thread it can be expressed by the terms of the cohesion and the hardened coefficient, and it should be proportional to the cohesion coefficient and inversely proportional to the hardened coefficient."

Evenness

Evenness of the cloth is in a direct relation to the number of fine and coarse threads found in a fixed yardage as I propose to show by the graphic description following:

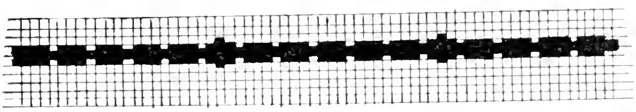


Fig. 16

The sketch shows the fine and coarse threads woven as the filling, single, in the proportion of five fine to one coarse, with three regular size threads between, to present a good illustration. As the purpose of the sketch is to show the relation of fine and coarse threads to the evenness of the cloth, the frequency in which the regular threads occur is immaterial and is therefore not given in the same proportion as they appear in the test as that would make the sketch too large. Each square represents the cross section of a thread, the fine thread to represent ten deniers, the coarse twenty deniers, the regular size fifteen deniers.

It will be observed that where the coarse sizes appear the unevenness is worse but we cannot view the increase in the thickness of the cloth from the thin part made by the fine thread but must view it from its average thickness

made by the regular size thread; a fine thread makes the cloth thin and weak, whilst a coarse thread makes the cloth thick, and when twisted is dull in shade, or causes streakedness. A cloth to be even must lack both the extreme fine and coarse threads; viewing them both from the average thickness of the cloth, the one is as serious as the other, therefore it will be observed that the less fine and coarse threads there are the evener the cloth and the more fine and coarse appear the more uneven the cloth.

In throwing organzine when two threads are doubled together of the proportion one to two and a half, even with the most even doubling, the coarse size will wind around the fine and give the thread a corkscrewed appearance; the greater the difference the more marked will be the corkscrew. The very fine threads, however, present another condition and that is they overstretch and do not contract the same as the regular size and make a bad corkscrew, therefore again we have the same relative condition and the evenness of the organzine is in proportion to the number of fine threads found in the raw thread. The fine, in addition to making the threads thinner and corkscrewed, also makes the thread thirty-three per cent weaker, that is the fine thread generally breaks thirty-three per cent. lower than the combined strength of both threads of average size. The coarse thread twists up a duller shade, causes streakedness and gets stuck and breaks in the reel when using a fine reed.

Can the evenness be determined by the ecart or spring of sizing skeins? No, as the short fine and coarse even up. Can the relative evenness be determined by the weight total of the sizing skeins above and below the average and their aggregate weight be compared with that of the same number of skeins of average weight or any other mathematical computation from the sizing? No, as the more short uneven lengths there are the more they even up as the following illustration shows.

A lot of Shinshiu No. 1 showed on sixty sizings, skeins of 225 metres a range of from ten to sixteen deniers or a spring of six deniers. A Gauge test showed on 300,000 yards:

135 Very Fine threads under six deniers
315 Fine threads under ten deniers
210 Coarse threads over twenty deniers

One of the most uneven silks ever tested.

Here is the situation: when the fine and coarse threads are very few, say twenty to every 300,000 yards, then they come only once on the average in every 15,000 yards and generally get into one sizing and give a false relative value and when they are many they get so close together that they average up with the coarse and again give a false relative value.

In valuing evenness we must remember first that it is only the extremes that count in working results and the quality of cloth. A very fine thread which always breaks either in throwing or weaving is just as serious from a working point of view if only one or two inches long as when one hundred inches long. One hundred very fine are one hundred times worse than one very fine. Take the fine ranging from six to ten deniers on a 13/15 denier thread and the coarse

over twenty deniers are the ones that pass through and get into the cloth and cause the unevenness that becomes noticeable and lowers the quality of the fabric.

In valuing evenness we need consider only the threads one-third under and over the average size and our test for evenness must be one that will show this truly in the easiest, simplest and quickest way. The fine and coarse threads average between five inches and twenty-five yards. One fine or coarse streak five inches long would not be as bad as if it was twenty-five yards long, but 180 fine streaks five inches long or the equivalent of the twenty-five yards length would be decidedly worse than the one spot twenty-five yards long, so also would 600 streaks in fifteen yards of cloth be much worse than thirty streaks of the same average length.

The point I desire to make is that unevenness is in proportion to the number of very fine, fine and coarse threads regardless of their length and that a test for evenness must show these three conditions regardless of their length, which cannot be done with sizing skeins no matter what length they are reeled. A number of Japanese inspectors were approached on the uniformity idea shortly after the several articles were published and they said that they could meet the uniformity idea with No. 1 stock and according to the results we have had recently, they appeared to have accomplished it very well, indeed, much to our regret.

Is then the practice of judging the evenness by the spring faulty and this custom that has been in vogue for years without any merit? No, when the fine and coarse threads are few they come so far apart that rarely more than one fine or coarse gets into one sizing skein, and they either increase or decrease the weight of same as the case may be; then the spring is a true indicator of evenness. Experienced inspectors never used it as a definite method of judging evenness, only as a sign or an assistance to the inspection. I have found it holds true only in inspecting XX and XXX silk and when the stock is under these two grades then the fine and coarse threads come frequently enough to even up, even on 225 meter sizings, and no dependence can be placed on same.

The following test demonstrates how unreliable the judging of evenness by sizing skeins is:

A silk was selected which showed on 480 sizing skeins of 225 meters each, an even thread, sixty-six per cent of which was within the limits of thirteen and fifteen deniers. The weight and number of sixty of these sizings, which are representative of the 480 named, are given under Fig. No. 17, and drawing the variation on a greatly enlarged scale, we have a thread varying in diameter as shown by Fig. No. 17. These same sixty sizings showed eighty threads under ten deniers and sixty threads over twenty-four deniers, which, drawn to scale on the same basis as Fig. No. 17, gives a thread varying in diameter as shown by Fig. No. 18. Notice the remarkable difference between the two results on exactly the same silk. The organzine was woven as the filling in a chiffon taffeta. The cloth was very uneven and streaked and showed with a very sensitive micrometer from five to seventeen per cent variation in

the thickness of the cloth, proving that the silk was very uneven, as represented by Fig. No. 18 and that, judging the evenness by the sizing test, is very unreliable and misleading.

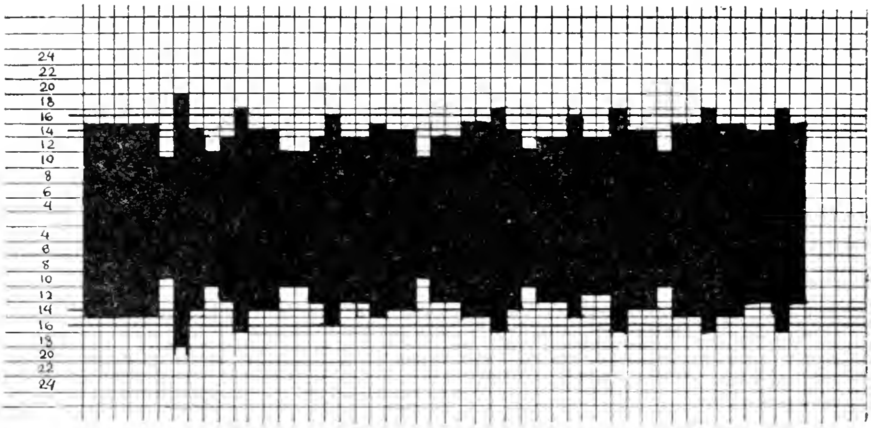


Fig. 17—SIZING SKEINS 225 METRES.

11 Den.	3 Sks.	15 Den.	12 Sks.
12 Den.	4 Sks.	16 Den.	7 Sks.
13 Den.	10 Sks.	17 Den.	3 Sks.
14 Den.	18 Sks.	18 Den.	3 Sks.

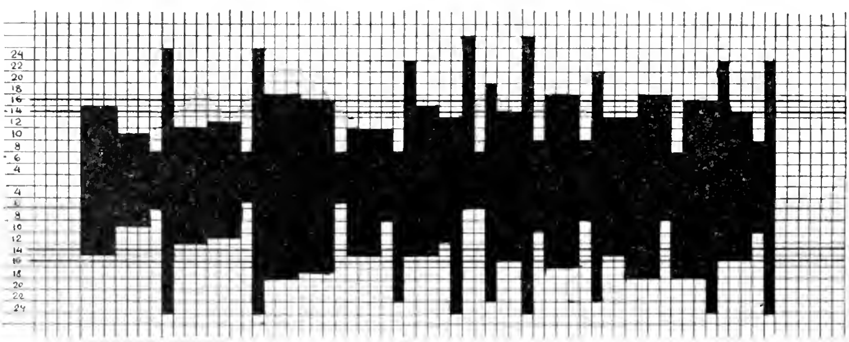
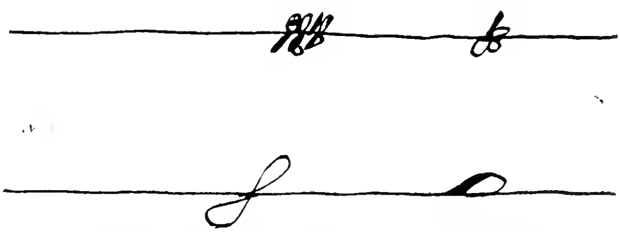


Fig. 18—GAUGE TEST ON SAME SIZING SKEINS.
Fine 80 Under 10 Deniers. Coarse 60 Over 24 Deniers.

Cleanness

This term cleanness is a misnomer when applied to the defects in raw silk. True, the number of defects indicates whether the thread is clean or unclean and the term expresses this condition in a general way, yet as most of the defects are such that they affect the strength, cohesion and working qualities in spinning and weaving, I desire to point out that this term is often misleading and that sufficient importance is not given to the reeling defects and their relation to the qualities of the raw.

*If we watch a silkworm spinning his cocoon, we will see him working with a regular swaying motion of the head, from right to left, up and down, placing his thread in the form of a figure 8; as soon as he has made a thin layer of silk in this way, he changes his position and begins the same work again. The shell



ILLUSTRATIONS OF DUVET AND BOUCHON.

of the cocoon is thus formed entirely of silk layers, one over the other, these layers being composed of a multitude of tiny clusters of thread, glued firmly together. The work of the reeler consists in part of softening the shell in boiling water, in order to allow this species of skein, that is so admirably made, to be wound, and to obtain the raw silk of our filatures.

Unfortunately, a small part of the figure 8 that forms the shell does not dissolve, and these places appear in the silk thread either separately or joined together in a tiny lump, forming in the first instance loops (duvets) and in the second slugs (bouchons) greatly enlarged.

In addition to the two defects mentioned, which form the great majority of those found in silk, there are three others, which are very rare, and which are split threads (la coste), corkscrew (la vrille) and bad throws (les mauvais lances).

Split threads result from a badly cleansed cocoon, in which the silk layers have not been freed in the beating. They are sometimes confused with corkscrew when the latter is very fine; but they are easily distinguished under the microscope with the addition of a drop of some alkaline solution, which frees the fibres. Split threads are parallel, while corkscrew is in rings. The origin of the latter is very doubtful, in spite of all the reasons given in explanation, none of them, in my opinion, being demonstrated by a direct test.

Bad throws have almost entirely disappeared with the mechanical means of throwing; they only formed, at the outside, about one per cent of the defects

*By Paul Francezon.

found in silk, and if undue importance was at one time attached to them, it was only on account of the ignorance that prevailed concerning the actual number of loops, split ends and slugs that were present in the raw silk.

La Coste

La Vrille

Les mauvais lances

Number of Defects Found in Cocoon Fibres

The following table shows the average of defects found in yellow Cevennes raw silk from 1872 to 1888 in the first-class filatures of our country; each result is culled from the inspection of three or four thousand meters of threads, taken from a great number of skeins, spun by different spinners, and taken sometimes from several bales by my confreres themselves, who wished to interest themselves in these studies. It is easy to understand the importance of separating these samples, representing as closely as possible the average of manufacture. This precaution is absolutely necessary for all silk study.

If it is the silk of the workroom that is to be studied, the selection of the sample is easier, for it is only necessary to rewind the threads taken for the assignment of several days; they practically represent the average silk reeled, for they are selected from the skeins of several reelers and show the different points of these.

There are years when, for some unknown reason the cocoons have shown a very large number of defects, a curious fact in all the filatures studied; it might be the fault of the cocoons themselves through accident that we are not responsible for, during the growth of the worms. I regret greatly not being able to make careful comparative tests with the silk of other countries, for it would be very interesting to see if the defects followed the same order as with us.

Years	Defects in 100 Metres	Defects in 1 gr.	Size gr.
1872	71	496	0.688
1873	69	509	0.675
1874	63	428	0.701
1875	85	604	0.700
1876	84	648	0.647
1877	76	541	0.702
1878	47	327	0.720
1879	59	441	0.676
1880	64	450	0.709
1881	68	457	0.730
1882	85	620	0.680
1883	90	651	0.676
1884	75	508	0.745
1885	78	540	0.720
1886	80	456	0.870
1887	109	660	0.830
1888	64	436	0.738

It is not possible for me to give here the studies of seventeen years of different silks; but it is interesting to sum up some of the principal results in the following paragraphs:

The cocoons having the richest gum, compact and rather coarse grained, yield the smallest number of defects.

Satiny cocoons yield from fifty to sixty per cent more defects than the fine grained ones.

Pale and highly colored cocoons of the same variety show the same number of defects.

There is only from eight to twelve per cent difference in the defects of silk from first class filatures.

Silk from second class filatures has from twenty to twenty-five per cent more defects than that from those that are first class because of the very poor sorting (sometimes none at all) to which the cocoons are submitted.

All things being equal, the filatures that have the most rapidly rotating winders will give the cleanest silk.

Certain first class filatures giving the cleanest silk present very unreliable figures on the percentage of stretch on ten per cent of moisture.

Japan and China silk reeled in the European manner is admirably clean (twenty-five to thirty defects in one hundred meters).

Italian silks come next, with about eighteen per cent less defects than our Cevennes silks; but these latter, fortunately, have special qualities, due to the nature of our cocoons, to the very high temperature in which they are spun (88-90 degrees, C.) and to the extremely careful selection that we make.

The longer the cocoons lie, boiled and clean, the greater the number of defects; all the advantage belongs to those least beaten and rapidly despatched.

The last layers of the cocoons show many more defects than the first, perhaps because they have been subjected longer to the action of the warm water.

Distilled water is the best to use; we shall study this question later, with the care that it warrants: I can, however, say that from July, 1868, until today, I have used it exclusively (note—an example followed little by little by many of my confreres); it costs nothing, since it is only necessary to gather the condensed water from the steam pipes and escapes of the machine. Every reeler, having only lime water at his disposal, must do away with it entirely for his basin supply; this is an indispensable condition for producing excellent silk.

It will be observed from the studies made by Paul Francezon that the defects in raw silk range anywhere from 60,000 to 320,000 or 300,000 yards.

Mr. Rosenzweig says, in the December, 1915, issue of the American Silk Journal, that "on the worst silks there are as many as five million loops to the kilo. As these minute defects cover in the cloth, excepting when they become very excessive, it serves no useful purpose to know their number. We will therefore confine our attention to the defects that affect the Strength, Cohesion and Evenness of the thread and are larger than the diameter of the thread, in other words the extreme defects of the thread."

The uncleanness of a silk thread is represented by the following defects:

Slugs	Cocoon defects
Nibs	
Bad Knots	Reeling defects
Waste	
Split Threads	
Bad Throws	
Corkscrews	
Hairiness	

The following plates have been carefully selected as representing the defects as they appear in raw silk of the various grades reaching the American silk trade. The plates represent the defects slightly enlarged.

Plate No. 3—Small Raw Knots

A commercially perfect skein of silk we will consider as one of continuous length knotted together by short knots, one-eighth inch or shorter. Small raw knots are therefore no defect, but a means to a perfect thread.

On Italian silks they run from ten to one hundred.

On Japanese silks they run from 100 to 700 on 300,000 yards.

Plate No. 4—Bad Knots

Bad knots are usually over one-half inch long with ends glued together, which gives a definite means to distinguish them from throwsters' knots; sometimes they are from four to five inches long. They, however, are not always

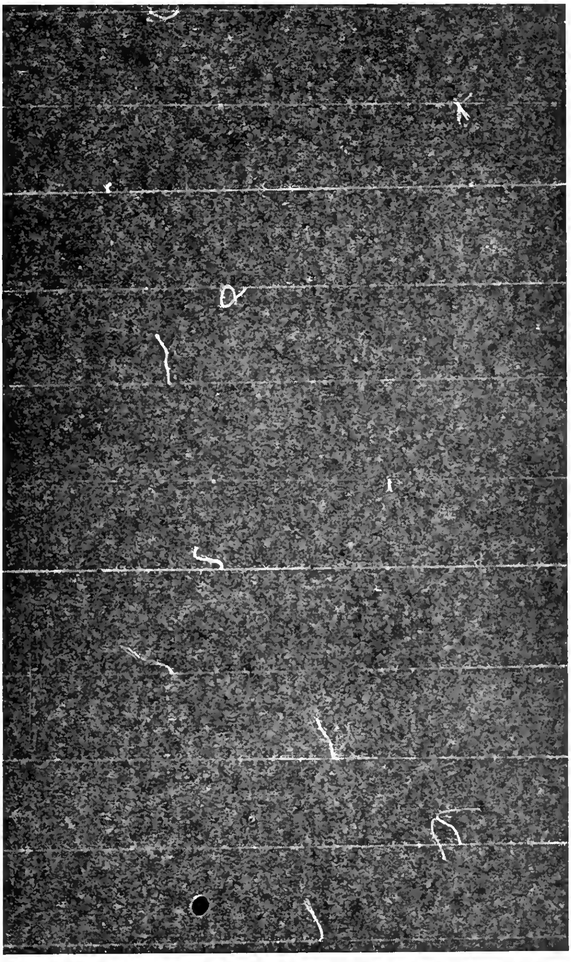


PLATE 3—SMALL RAW KNOTS

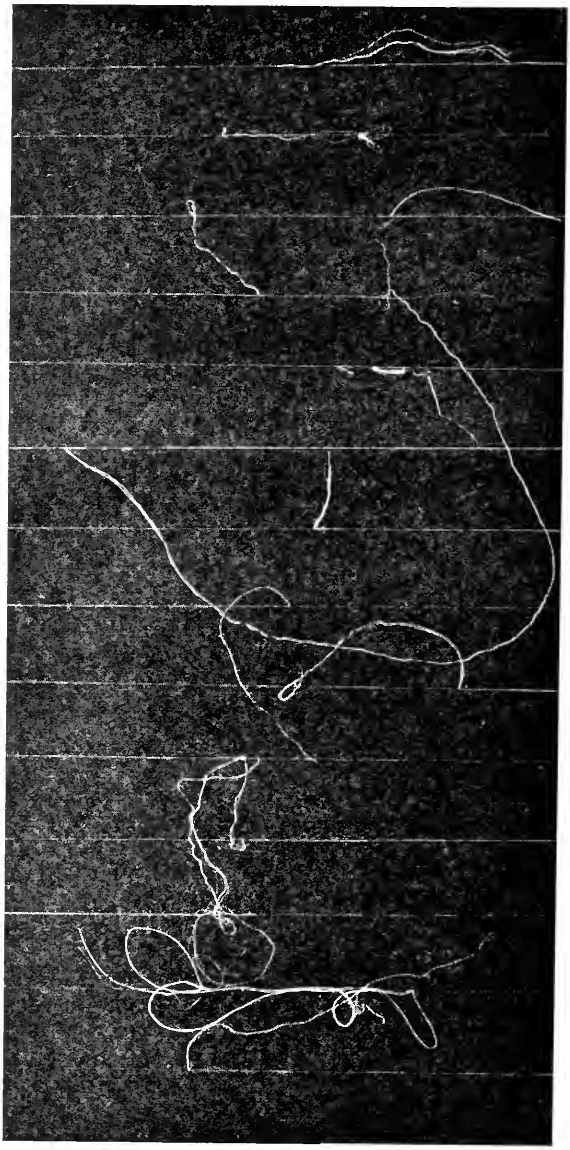


PLATE 4—BAD KNOTS

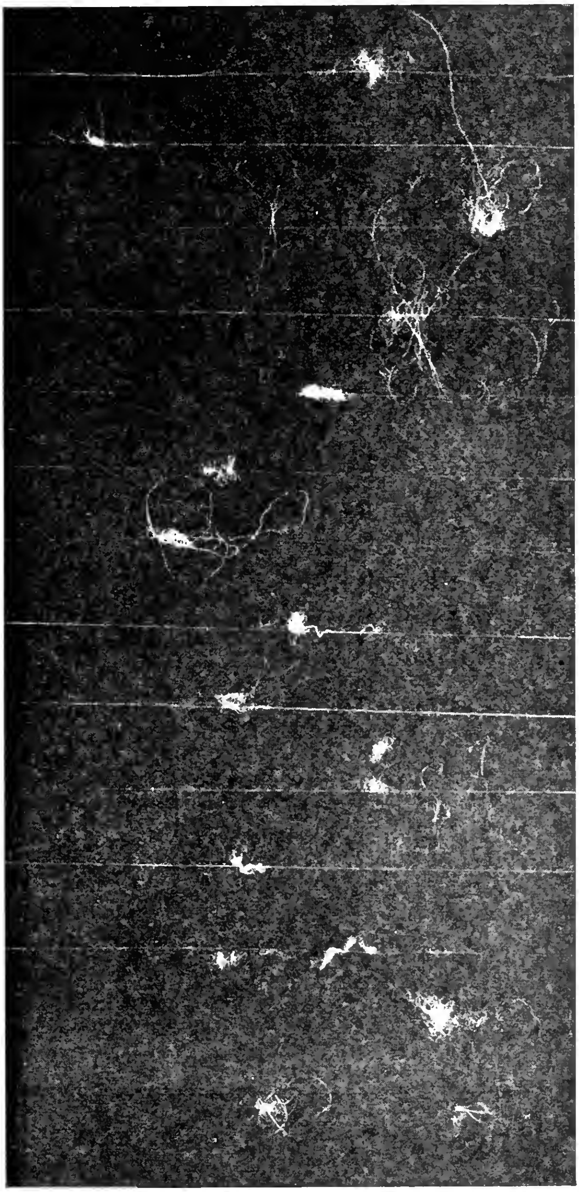


PLATE 5—WASTE

glued together, as sometimes they are made when re-reeling the skeins dry. These knots make constant trouble and about forty per cent break out in throwing. They run about as follows on the following grades of silk:

Grand Double Extra	0
Double Extra	3 to 10
Extra	10 to 20
Best No. 1 to Extra	20 to 30
Best No. 1	30 to 40
1	40 to 100
1 to 1½	100 to 150

The larger ones are found mostly in the lower grades of raw.

Plate No. 5—Waste

This is generally a loose formation of fibres wasted in tieing a knot; at times it appears to be floss from the basin which has been permitted to gather there and pass up on the running thread. These defects are very troublesome and about one-third break out in throwing. They run about as follows in the various grades of silk:

Grand Double Extra	0
Double Extra	0
Extra	10 to 20
Best No. 1 to Extra	20 to 30
Best No. 1	30 to 60
No. 1	60 to 100
1 to 1½	100 to 150

The larger ones are found mostly in the lower grades of raw.

Plate No. 6—Nibs

Call small slugs about the size of a raw knot or slightly larger a nib; if there are two nibs closer together and they are large or oblong call them slugs. The idea is to call those that will not show on the thread when thrown nibs and those that are large and will show, slugs. The nibs show about the following on the various grades of raw:

Grand Double Extra	20 and under
Double Extra	20 to 30
Extra	30 to 50
Best No. 1 to Extra	50 to 100
No. 1	200 to 300
1 to 1½	300 to 400

This is one of the defects that seems to appear more numerous in hard nature silks. As they are small they rarely show in the finished cloth, except on high-class goods and then only when they are very numerous. Practically none of these are removed in throwing. They are counted in the quality numbered so as to maintain its relative value as is explained under the proper head.

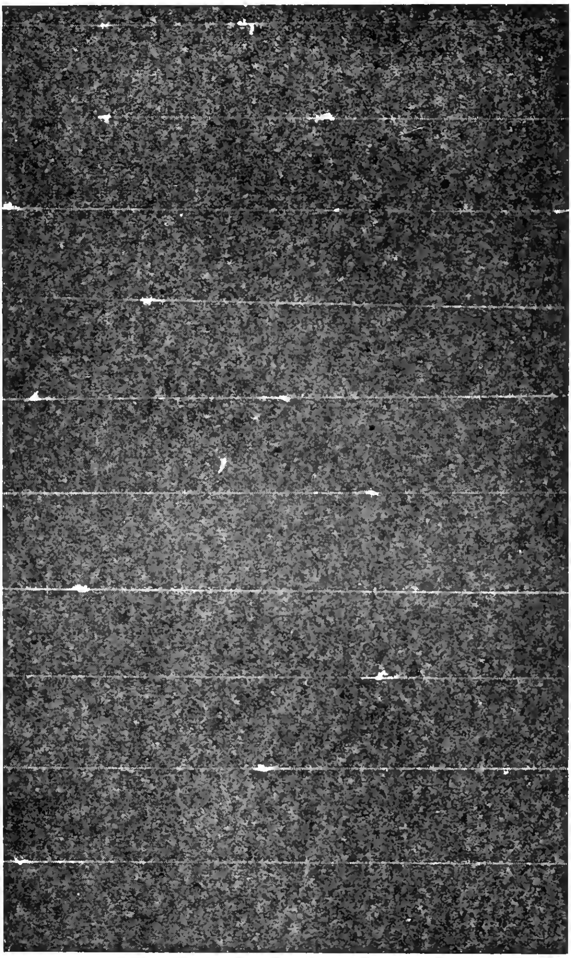


PLATE 6—NIBS

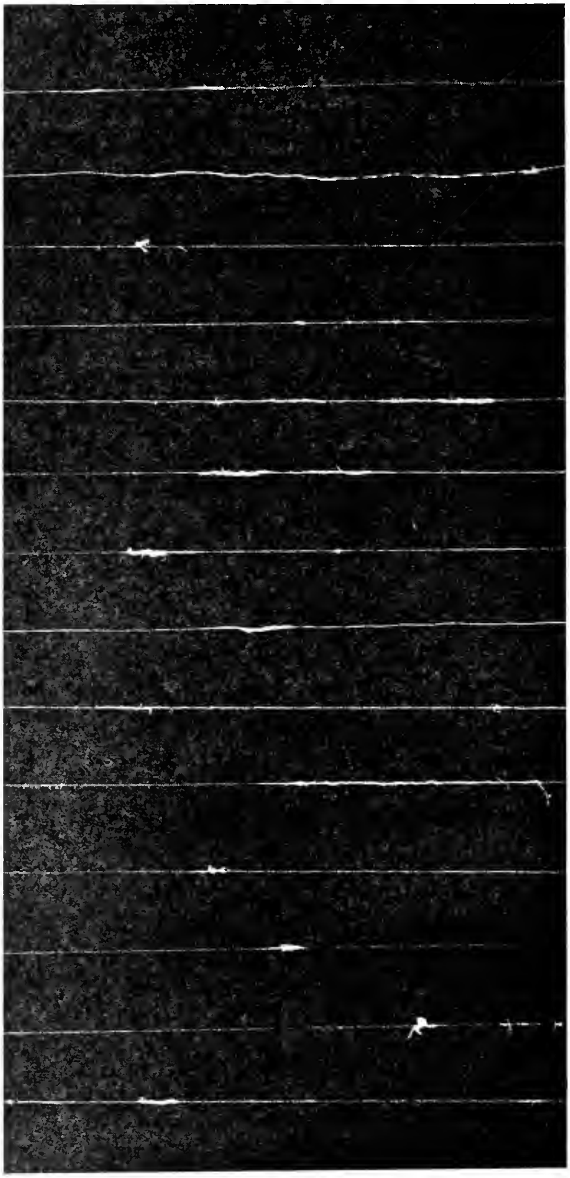


PLATE 7—SLUGS

Slugs

The slugs show about as follows on the various grades of raw:

Grand Double Extra	Under 30
Double Extra	30 to 50
Extra	50 to 80
Best No. 1 to Extra	80 to 120
Best No. 1	120 to 200
No. 1	200 to 400
1 to 1½	400 to 600

This defect shows up about twice as much in the dyed state. As they are generally glued together firmly not more than five per cent are removed in throwing.

Plate No. 8—Loops

Sometimes you will have a break without any apparent cause, but on closer examination you will notice a cocoon fibre longer than the rest. This invariably is due to the thread breaking at the loop.

Loops are of such size that they not only cause the silk to be unclean, but also affect the strength of the thread and must be considered a serious defect. They run about as follows on the following grades of silk:

Grand Double Extra	50 and under
Double Extra	50 to 100
Extra	100 to 200
Best No. 1 to Extra	200 to 300
Best No. 1	300 to 400
No. 1	400 to 550
1 to 1½	450 to 600

*Loopy silk is justly regarded as very serious. Loops are caused in several different ways; the first and most usual one is that the reeling girl, through carelessness or want of experience, in throwing on a fresh cocoon (to replace one that has broken off or been used up), snaps the cocoon end off too long and thus overlaps the point by some inch or two of superfluous cocoon end.

When this takes place the excrescent end (Fig. 19) being attached to the main thread, passes through point C (see Fig. 20) but then falls back, and on reaching the twist immediately afterwards is, to all appearances, kneaded and pressed into the main thread. In reality, however, here is where an invisible loop is formed, as described.

Another case of loopy silk occurs where one or more of the cocoons have been soaked rather longer than the others; in this state they will, of course, offer less resistance to the winding than the rest and will run off more easily. Now, when the swift happens to be going around very fast, those cocoons that have been soaked the least will often offer so much resistance in the unwinding that they will be suddenly jerked up from the basin to point B ahead of the rest, and this naturally forms a kink; however, this kink is kneaded and pressed in, and so disappears from sight, only, however, to reappear again as a loop in the way described when the silk is soaked for throwing.

*B. A. Armstrong of the Brainerd and Armstrong Co. and F. A. Vivanti of Vivanti Bros. in Silk Journal 1900.

Having shown that carelessness or inexperience of the reeler or uneven or over soaking of some of the cocoons is the usual origin of loopy silk, I must, however, add that the great and fatal defect of too short a twist in reeling is, after all, often the main, though indirect, cause.

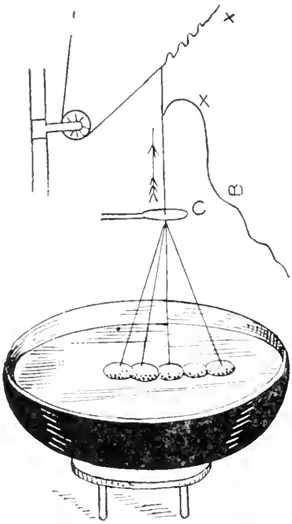


Fig. 19
A—Excrescence or overlapping end.

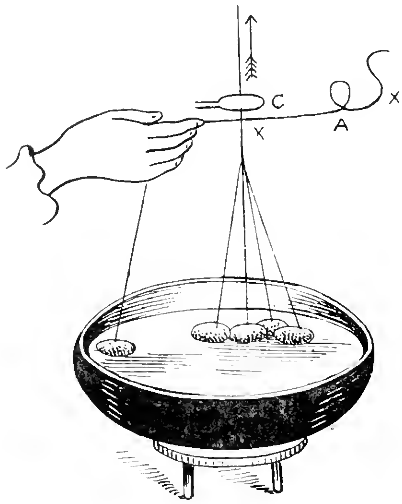


Fig. 20
Same excrescent end having passed through the hole in small porcelain plate, C, has fallen back and on reaching the twist (*) will be pressed in.

It is only when the swift revolves very fast that there is much risk of some of the cocoons being suddenly jerked up ahead of the others, as described, and it is only when the twist is too short that this excessively fast pace can be easily maintained. A long twist causes a certain strain on the thread and moderates the pace of the swift "nolens volens."

In conclusion it is far more difficult to guard against the faults of bad reeling that cause loops, than to insure a long twist; for the former the superintendent would have to watch each reeler continually and note every cast (a practical impossibility); for the latter the superintendent has only to pass each basin occasionally and look at the length of the twist.

Plate No. 9—Split Ends

The split ends affect the strength of the thread; the maximum number is about one hundred.

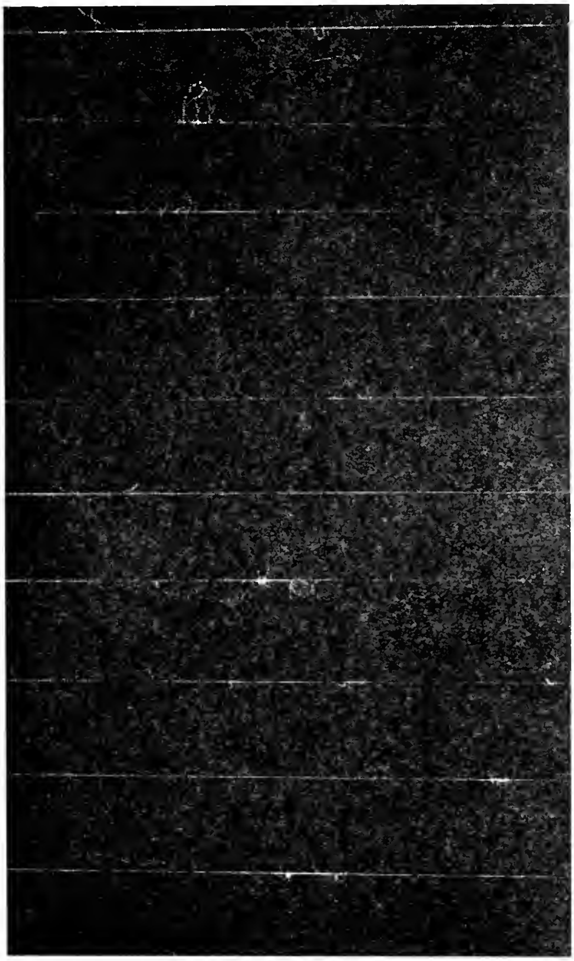


PLATE 8—LOOPS

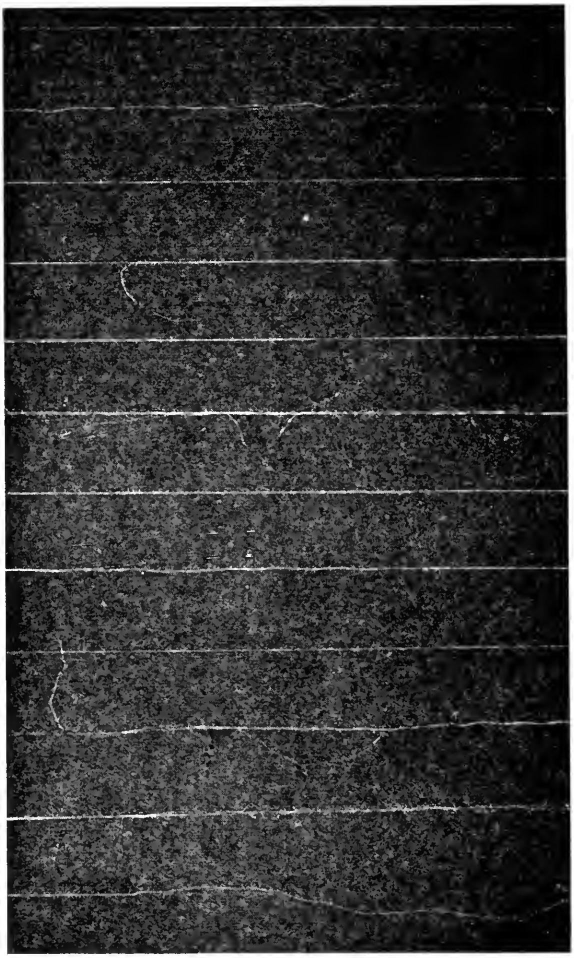


PLATE 9—SPLIT ENDS

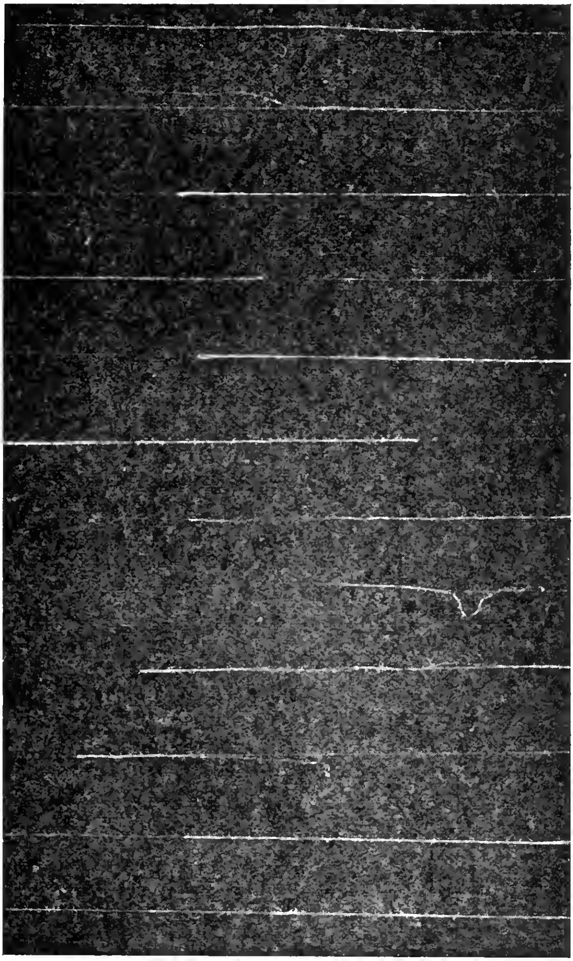


PLATE 10—BAD THROWS OR CASTS

Plate No. 10—Bad Throws or Casts

These are the result of carelessness in reeling and generally indicate inexperienced operatives. The thread usually is quite uneven when they are numerous. They run about as follows in the following grades of raw:

Grand Double Extra	0
Double Extra	Under 5
Extra	5 to 15
Best No. 1 to Extra	15 to 30
Best No. 1	30 to 60
No. 1	60 to 100
1 to 1½	100 to 200

Corkscrew Threads

These are caused by an uneven tension in reeling similar to that of making loops. They run about as follows in the following grades of raw:

Grand Double Extra	0
Double Extra	5
Extra	5 to 15
Best No. 1 to Extra	15 to 30
Best No. 1	30 to 45
No. 1	45 to 60
1 to 1½	60 to 80

They affect the strength and cohesion of the silk.

There is a general impression among manufacturers that the throwing process cleans the silk thread, and eliminates the fine ends to such an extent that its quality is raised several grades; this, however, is not the case, as it would make the cost prohibitive and the waste excessive. Several thousand tests show that on an Extra up to grade about forty-five defects are removed; on a No. 1 about one hundred defects are removed in throwing into an organzine; and these extra fifty-five defects cost the throwster just about twenty cents per pound additional. Suppose, as frequently happens, that he receives two lots of Extra of the same chop, one shows 250 defects, the other 900 defects to 300,000 yards. He returns the first lot with 200 defects, the second with about 800 defects. Assuming that one-half of the remaining 600 defects in the second lot were nibs, this would leave 300 defects to be removed. An experienced operator can tie up at the rate of say 150 breaks per hour; that would mean that on every 300,000 yards, or a pound of 14/16 denier silk, it would take two hours to clean a pound, or cost, at fifteen cents per hour, thirty cents a pound. The waste would be in this case about four and one-half per cent.

The following shows two tests of the same chop of Extras:

Lot A—Chop B

Winding count	25
Fine ends	35
Coarse ends	5
Waste	..
Long knots	5
Nibs	100
Slugs	25
Loops	105
Bad Throws	15
Total	315

Lot B—Chop B

Winding count	17
Fine	60
Coarse	200
Bad knots	2
Nibs	502
Slugs	389
Loops	364
Bad throws	4
Total	1538

These extreme variations are found occasionally in most of the private chops and show how faulty the raw silk inspections are and the need of standardized methods; they also illustrate how great an injustice can be done the throwster by expecting him to produce a good thrown thread from silk having sometimes five times as many defects.

PART II—CHAPTER III

CLASSIFICATION OF RAW SILK

Raw silk as generally traded in on the New York market is classified as follows:

European Silks

Grand Extra	Best No. 1
Extra Classical	No. 1
Best Classical	Realina
Classical	

Japan Silks

Filatures—	Rereel—
Double Extra	Extra
Extra	No. 1
Shinshiu Extra	No. 1-1½
Best No. 1 to Extra	No. 1½
Best No. 1	No.1½-2
Hard Nature No. 1	No. 2
No 1	Kakeda—
No. 1-1½	Best Extra
No. 1½	Extra
No. 1½ 2	No. 1
No. 2	No. 2
	No. 3

It is to be noted that Best No. 1 Japan silks of the New York market correspond only with No. 1 of the Yokohama market, other grades accordingly.

Canton Filatures

Special Grand Extra	Ex. Ex. B Ordinary
Ex. Ex. A Crack	Extra A
Ex. Ex. A Ordinary	Extra B
Ex. Ex. B Crack	

China Steam Filatures

Extra	No. 2
Best 1	No. 3
No. 1	

These classifications are generally made by raw silk inspectors who employ principally organoleptic methods, that is, a grading made by the sense of touch and sight, and is principally a method of comparisons. No definite rule governs these comparisons, but they are subject to the arbitrary methods or will of each inspector who by his extensive knowledge of the cocoon crop, the nature of the cocoon raised in the respective districts, method of sorting, care and attention exercised in reeling, and general supervision at the filatures, is able by the sense of touch and sight to select the first choice silk for the highest grade and classify the others into the lower grades, giving a good classification.

Not all inspectors, however, are able to secure this general information; then it becomes necessary for each inspector to apply his own method of testing the thread, value each quality of silk and classify according to his individual judgment. As there are no fixed rules to follow, inspectors must work out and follow their own; as each inspector jealously guards his own methods it becomes a difficult problem for beginners to acquire the necessary knowledge and give a good classification.

To give a general idea of how these inspections and classifications are made I submit the following:

A thread dense and firm with a good deep lustre is generally strong and has a good cohesion.

A thread strawy to the touch, dull in lustre, generally is weak and of low cohesion; a thread breaking off straight with a spring, also shows strength, while one breaking off gradually, leaving one or more cocoon fibres longer than the other, usually is low in cohesion and strength; yet there are exceptions to some of these conditions. Lustre, for example, may be governed entirely by the water and temperature at which the cocoons are reeled. For cohesion there is the nail test by which a thread is scratched by the nail of the thumb when drawing the thread between the thumb and index finger. The number of scratches it takes to open the thread indicates whether the cohesion is high, medium or low. For evenness and cleanness there is the visual inspection on the outside of the skein; having now fixed in his mind the various qualifications, if they are all high, he classes the silk as an Ex. Ex.; but let us suppose that the strength is only fair, but good in every other quality; then he reduces the classification one or more grades as the condition may indicate.

It will be observed that these methods are very crude, and that the lack of scientific methods gives the opportunity for all kinds of irregular practices; reelers also frequently are more careful in reeling the top of the skein than the rest, and thereby deceive the inspectors. The need then of scientific methods to classify raw silk is very apparent. Investigations made by Rosenzweig and others, besides the writer's own experiments, prove that the four basic qualities of raw silk can be measured by mechanical means, their true relative value determined, and from these a standard method of classifying raw silk arrived at that is reliable.

PART II—CHAPTER IV

STUDIES ON WINDING

Figure 21 shows the different styles of skeins reaching the American market. The winding results vary from about fifteen to 400 breaks per pound, the waste made from one-third of one per cent to four to five per cent. The production per winder from three to fifty pounds per day of ten hours. The defects that cause silk to wind poorly are as follows:

First—Very fine ends.

Second—Insufficient and irregular crossing.

Third—Ineffective lacing. Where the lacing is simply tied around the skeins.

Fourth—Hard gums or reel markings.

Fifth—Sticky thread, which appears to be due to a lack of change in the water in basins.

Sixth—Large slugs and waste catching on running threads.

Seventh—Double thread sometimes occurring 300 to 400 times in a ten bale lot and often several hundred yards long.

Eighth—Threads matted around the skeins, due to skeins being packed in books while moist.

The winding test may be made on the unsoaked silk, but care must be taken when rubbing out gums that the threads are not broken; when the gums are very hard it is best to sponge them with a solution of soap and rub, comb and pull them apart while the gums are softened. If the wound silk is wanted for sizings then the increased weight may be determined by weighing the skeins before sponging and when dried before winding, then the correction can be made on sizing tests. When the threads are matted together around the skeins, as happens when the skeins are packed when wet, then these matted parts should also be rubbed out before winding.

Winding Count

The Throwsters' Rules and Regulations of 1908 read, Article No. 7—Winding: "As a rule this class of silk must be such that one winder can attend to one hundred swifts with a thread speed of sixty yards per minute." This method is unreliable for the following reasons:

First—A sixty-thread speed is impracticable, as at that speed the take-up bobbin is too soft to spin and double with success unless the swifts are weighted.

If weighted, then the breaks are increased over that of high speed and no weights, as follows:

Stock 12/14 denier Italian.
165 thread speed, no weights, pin hub. Count 64
132 thread speed, with weights, pin hub. Count 75
Increase breaks 11, or 17.2 per cent.

Second—A part of one hundred swifts at a sixty-thread speed is a very low working basis and practically that of poor winding qualities of Canton skeins. Experienced winders tie up at the rate of about 180 ends per hour. One hundred spindles at sixty yards per minute = 360,000 yards per hour, or about a pound of 13/15 denier silk. On that basis the winding costs per pound on the best 13/15 denier silk will be whatever your rate per hour is.

During my investigations for a true winding count I discovered the following conditions:

In order that the count may be dependable it should show the relative winding qualities on every grade of silk; it must include breaks due to the gums, fine ends, loose ends, knotted places, ringy reel and second skein, and show a relative value on the single and double skein. It must be made at the same average speed. On a regular organ winder bobbin at 167 average thread speed, the silk winds, when the bobbin is empty, at 130, and when full, at 200 thread speed; the average skein runs from four to four and a half hours; every hour's winding increases the breaks eight counts by reason of the greater number of yards passing and therefore gives no true result when basing it on the breaks per hour; the breaks the first hour are frequently quite excessive; on the average they are thirty-three per cent more than the second hour, but it is not a general condition, it varies from two per cent minus to one hundred per cent plus; there are from one to five skeins in each test that show an abnormal number of breaks, not, however, confined to the first hour, as might be supposed, due to rough handling, but it must be remembered that broken threads may be and about an average number are, torn at the side of the skein, when the breaks will follow through the whole skein.

The estimated yardage wound by the speed of the spindle as compared with the actual yardage, shows it to run from one-half of one to 1.6 per cent higher on the estimated; silk wound wet, as it is when taken from the extractor and kept in baskets or boxes until ready to wind, shows twelve per cent more breaks than silk wound air dry with about fifteen per cent of moisture; a hand can tie up quicker on dry silk, as it is easier to find the end.

Double skeins show sixteen more breaks than single skeins, due to the first skein running out and the second skein starting up.

Speed

A series of tests show that with the six arm pin hub swifts, unweighted, when the speed exceeds 225 yards per minute, the breaks are increased. Tests on Canton and Tussah show that the maximum efficiency can be obtained at 167

average thread speed, which winds when starting out at about 130, and when bobbin is full at about 200. (I do not say that the end efficiency is found by winding at this speed, as in regular mill practice I use a higher one, but it is a speed that will give the reeler full credit for his skein and meet the requirements of the American silk manufacturers on all kinds of skeins.)

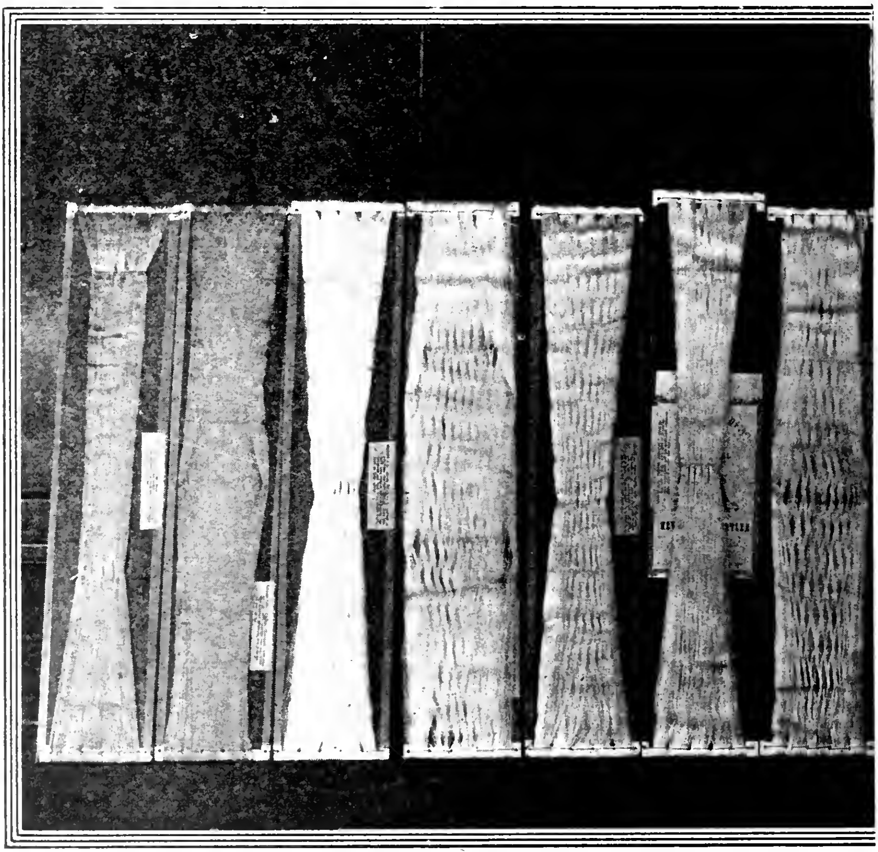


Fig. 21

EXHIBITS OF ITALIAN, JAPAN, TSATLEE AND CANTON SILKS—SHOWING THE ADVANTAGES OF THE AMERICAN STANDARD SKEIN AND THE DEFECTS OF THE OLD METHODS OF REELING. SAMPLES COLLECTED BY D. E. DOUTY.

Thread Speed

By thread speed is meant the number of yards taken up in one minute when the bobbin is half full. As the skeins, bobbins and spindle heads vary in size, it is the only uniform unit of measurement.

To determine the thread speed approximately, from the speed of the swift,

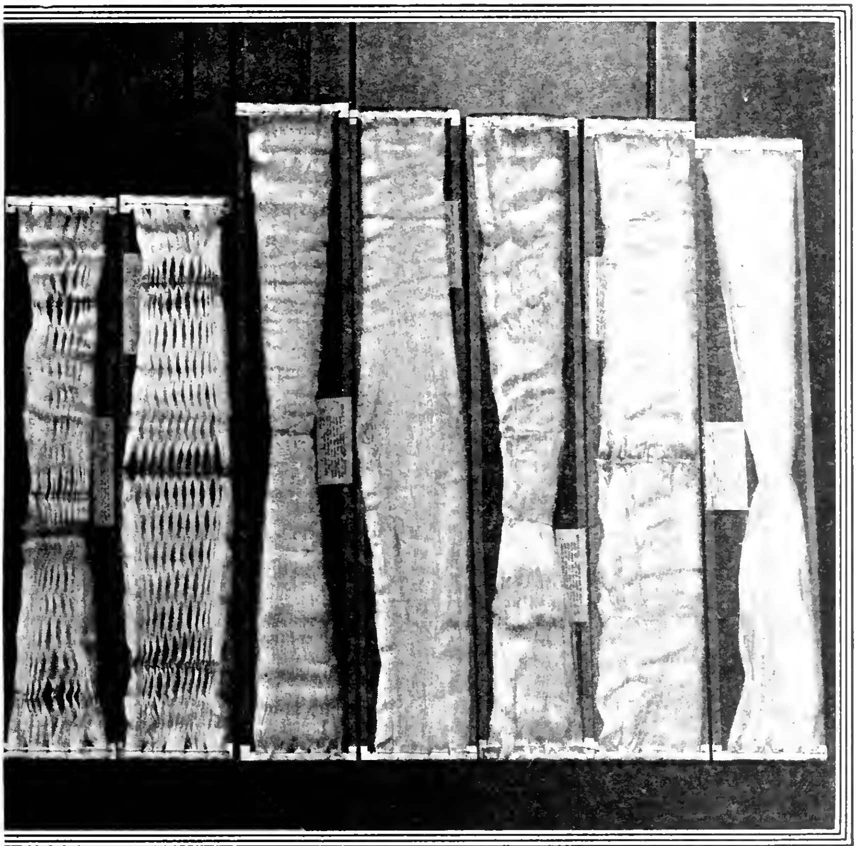


Fig. 21

EXHIBITS OF ITALIAN, JAPAN, TSATLEE AND CANTON SILKS—SHOWING THE ADVANTAGES OF THE AMERICAN STANDARD SKEIN AND THE DEFECTS OF THE OLD METHODS OF REELING. SAMPLES COLLECTED BY D. E. DOUTY.

measure the circumference of the skein on swift and reduce to yards; this times the number of revolutions of the swift per minute gives the thread speed.

To determine the thread speed from the friction roll speed of the machine, estimate from the thread speed of the half full bobbin.

The dimensions of Organ Winder bobbins are as follows:

Diameter Bobbin head	2⅛″	Circumference	6.67″
" Barrel	1⅜″	"	4.32″
" Average	....	"	5.50″
Diameter of bobbin at end of 15 minutes starting run	1 14/32″	"	4.52″
Diameter of bobbin at end of winding test	1 12/16″	"	5.51″

The silk on a full Organ Winder bobbin weighs 0.106 lb, and the bobbin contains 31,800 yards of single thread, 14/16 denier.

The Columbia winding frames have the following cones on shaft and machine, 4 steps, 6″, 5″, 4″, 3″.

The friction wheels are 4½″ diameter.

Spindles have 1¼″ head.

The friction roll speed is determined as follows from the thread speed:

T = Thread speed of half full bobbins.
36 = Inches to yard.
5.50 = Circumference of half full bobbin.
S = Spindle speed.
D = Diameter of friction roll.
Hd. = Diameter of spindle head.
R = Revolution of friction roll.

Formula: $$\frac{T \times 36}{5.50} = S \qquad \frac{S \times Hd.}{D} = R$$

On the Columbia winder T = 184.

$$\frac{184 \times 36}{5.50} = 1202 \qquad \frac{1202 \times 1.25}{4.50} = 334 \text{ roll.}$$

At a thread speed of 167 yards when the test is half finished on the Columbia winder with Organ bobbin the speeds are as follows:

Friction roll 334

Spindle speed $\frac{334 \times 4.50}{1.25}$ 1202

Winding Test

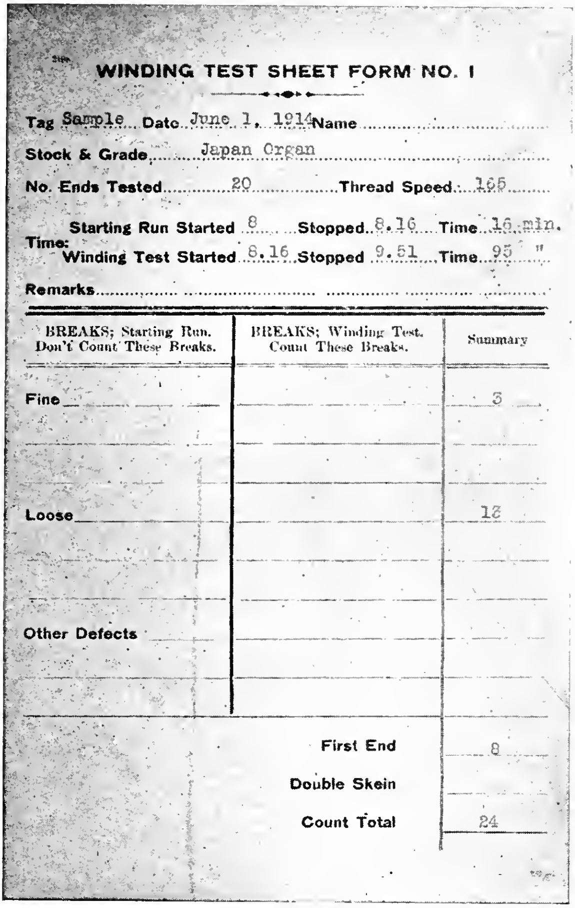
Starts at $$\frac{1202 \times 4.52}{36} = 151 \text{ Thread speed}$$

Stops at $$\frac{1202 \times 5.51}{36} = 184 \text{ Thread speed}$$

Average $$\frac{151 + 184}{2} = 167 \text{ Thread speed}$$

For Tussah and Short Length Skeins

For regular winding test use as close to 167 average thread speed as can be run with frame and bobbins used, without weights. Wind twenty skeins until three skeins run bare, then stop test. Time from start to finish. Multiply this time by the number of spindles run (twenty) and divide this result into the total breaks plus twenty for the first end tied up. This result is the breaks per spindle



WINDING TEST SHEET FORM NO. I

Tag Sample Date June 1, 1914 Name ....

Stock & Grade Japan Organ

No. Ends Tested 20 Thread Speed 165

Time: Starting Run Started 8 Stopped 8.16 Time 16 min.

Winding Test Started 8.16 Stopped 9.51 Time 95 "

Remarks ....

BREAKS; Starting Run. Don't Count These Breaks.	BREAKS; Winding Test. Count These Breaks.	Summary
Fine		3
Loose		13
Other Defects		
	First End	8
	Double Skein	
	Count Total	24

hour which times the following table gives the breaks per 300,000 yards: (four per cent allowed for slip and loss in tieing up.)

169 average thread speed times 30.7
166 average thread speed times 31.8
164 average thread speed times 31.70

Method of Making Count

Select twenty skeins from different parts of the bale, soak properly and dry until the silk has from fifteen to eighteen per cent moisture; rub out gums; skein up to ten skeins regular and ten with the under side up so as to get the average condition of the whole skein. Make a starting run of fifteen minutes, but don't count breaks. Run the actual winding test about ninety-three minutes longer, counting all breaks, the sum of which plus eight on single skein and plus twenty-four on double skeins is the breaks per 300,000 yards. This is added to make the count true on cost estimates, number of swifts and waste estimates. Also to represent the first end tied up on which waste is made and labor is required, also make the short method true to the breaks on the whole skein. The number eight is determined as follows:

To wind twenty skeins, which contain an average of about 57,000 yards each $\times$ 20 = 1,140,000. The winding test = 300,000, or 1,140,000, divided by 300,000 = .38 of twenty ends, or 7.6 ends.

The need of adding the first end tied up to the actual breaks is demonstrated by the following:

Timing experienced winders for five minutes, they tie up at the rate of from 228 to 348 ends per hour. I used sixty per cent of the average, or 180 ends, per hour as the basis. We have then:

Piecing up	1 end	0.34 minutes
Doffing	1 end	0.10 minutes
Skeining	1 end	0.80 minutes

To determine the number of swifts I use the following constant:

.0142 x count plus .03 plus .178 = R

$$\frac{60}{R} = \text{swifts}$$

0.0142 represents the time in minutes it takes every hour to tie up count 1 on 300,000 yards wound.

0.03 represents the time it takes in minutes every hour to attend to doffing.

0.178 represents the time in minutes it takes every hour to attend to skeining.

60 represents the number of minutes per hour.

Take the count 19, we have:

$0.0142 \times 19 + 0.03 + 0.178 = 60 \div .4778 = 125$ swifts.

Take now the count 19 and deduct the 8 = 11. We have: $0.0142 \times 11 + 0.03 + 0.178 = 60 \div .2642 = 227$ swifts.

The difference is 81.6%.

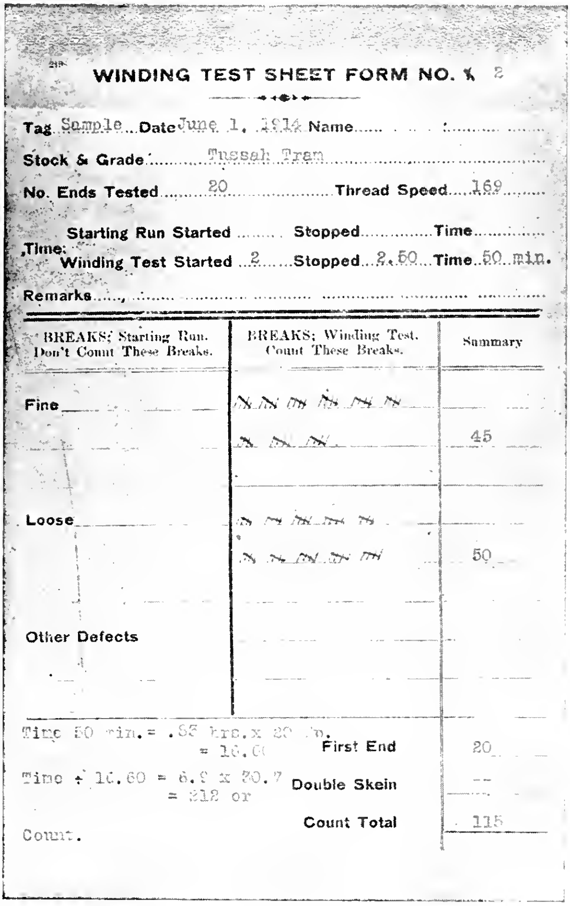
Take a higher count, say 56, the swifts = 54 taking 8 from 56 = 48, for which the swifts = 62, or a difference of but 10%.

The rule for waste is 1½ times count, expressed in per cent. Take a count of 25 $\times$ 1½ = 0.38%, deducting 8 would equal 25 — 8 = 17, or a rule of 2.23 times count. Take a count of 56, the waste = 0.84%, but if 8 is deducted it equals 1.75 times count.

You will see no rule could hold good and every count would require a different constant to determine waste, swifts and cost.

To estimate the waste on sizes finer and coarser than 13/15 use the following rule:

10/12 x .79
11/13 x .86
12/14 x .93
13/15 x Table
14/16 x 1.07
15/17 x 1.15
18/20 x 1.36
19/21 x 1.45



WINDING TEST SHEET FORM NO. ~~1~~ 2

Tag Sample Date June 1, 1914 Name

Stock & Grade Tussah Tram

No. Ends Tested 20 Thread Speed 169

Time: Starting Run Started Stopped Time

Winding Test Started 2 Stopped 2.50 Time 50 min.

Remarks

BREAKS; Starting Run. Don't Count These Breaks.	BREAKS; Winding Test. Count These Breaks.	Summary
Fine		45
Loose		50
Other Defects		

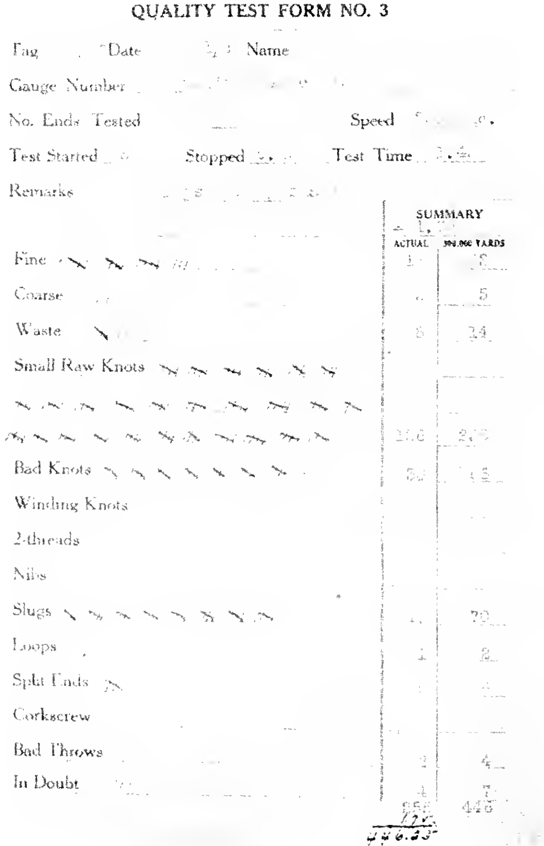
Time 50 min. = .83 hrs. x 20 En. = 16.60 — First End: 20

Time ÷ 16.60 = 6.9 x 30.7 = 212 or Count. — Double Skein: --

Count Total: 115

The American Standard skein frequently shows counts as low as fifteen; Cantons sometimes run as high as 400.

Tussah counts vary from 100 to 450.



QUALITY TEST FORM NO. 3

Tag Date Name

Gauge Number

No. Ends Tested Speed

Test Started Stopped Test Time

Remarks

	SUMMARY ACTUAL	300,000 YARDS
Fine	[illegible]	[illegible]
Coarse	[illegible]	5
Waste	[illegible]	[illegible]
Small Raw Knots	[illegible]	[illegible]
Bad Knots	[illegible]	[illegible]
Winding Knots		
2-threads		
Nibs		
Slugs	[illegible]	[illegible]
Loops	1	2
Split Ends	[illegible]	[illegible]
Corkscrew		
Bad Throws	2	4
In Doubt	[illegible]	[illegible]
	[illegible]	[illegible]

PART II—CHAPTER V

SIZE

The fineness or size of the silk thread is expressed by a number known as Titre (in French) or Titalo (in Italian).

*Principles of Yarn Numbering

There are many systems by which the "number," "size" or "count" of yarns is expressed. While many of them are used only in particular districts or countries, each is based on one of two general principles, viz.: either the weight of a definite length or the length contained in a definite weight. The number, or count, is therefore expressed below, either as the weight of a standard unit skein or hank, or the number of standard skeins required to weigh a standard amount. Folded yarns, "numbered on the single yarn," are expressed with the ply first and then the single yarn number from which they are spun. Thus, 3/60 means, 60s single-folded to 20. Folded yarns, "numbered as found," are expressed with the number as found first and then the ply. Thus, 40/2 means that the 40 is doubled from 2 single 80s. For average and resultant counts for mixed yarns of the same or different denominations see some manual on textile calculations. (Example: Bradbury, "Calculations in Yarns and Fabrics," pp. 37 to 52. Ashenhurst, "Textile Calculations and Structure of Fabrics," pp. 19 to 32.)

International Metric Count, for all kinds of yarn.

The yarn count is the number of meters in one gram.

No. 20 means a length of 20 meters weighs one gram (adopted by the Paris Conference of 1900).

SILK

RAW SILK

Legal Denier Count. Adopted at Paris Conference 1900.

The size is the weight of a 450-meter skein in deniers (5 centigrams).

THROWN SILK

Legal Denier Count. Same as for raw silk.

English Dram Count. Used principally in England and America.

The size is the weight of a 1,000-yard skein in drams.

Yorkshire Ounce System. Used only in England.

The size is the number of yards in one ounce avoirdupois.

*From Textile Table compiled by D. E. Douty of the United States Testing Company.

TABLE X

EQUIVALENTS OF VARIOUS DENIERS IN USE IN TERMS OF THE LEGAL DENIER BASIS

New Legal Denier	Old Milan Denier	Old Turin Denier	Old Lyons Denier	International Denier
10	10.3	9.9	9.9	11.1
2	10.6	10.1	10.1	11.3
4	10.8	10.3	10.3	11.6
6	11	10.5	10.5	11.8
8	11.2	10.7	10.7	12.
11.	11.4	10.9	10.9	12.2
2	11.6	11.1	11.1	12.4
4	11.8	11.3	11.3	12.7
6	12.	11.5	11.5	12.9
8	12.2	11.7	11.7	13.1
12.	12.4	11.9	11.9	13.3
2	12.6	12.1	12.1	13.6
4	12.8	12.3	12.3	13.8
6	13.	12.5	12.5	14.
8	13.2	12.7	12.7	14.2
13.	13.4	12.9	12.9	14.4
2	13.7	13.1	13.1	14.7
4	13.9	13.3	13.3	14.9
6	14.	13.5	13.5	15.1
8	14.3	13.7	13.7	15.3
14.	14.5	13.9	13.9	15.6
2	14.7	14.1	14.1	15.8
4	14.9	14.3	14.3	16.
6	15.1	14.5	14.5	16.2
8	15.3	14.7	14.7	16.4
15.	15.5	14.9	14.9	16.7
2	15.7	15.1	15.1	16.9
4	15.9	15.3	15.3	17.1
6	16.1	15.5	15.5	17.3
8	16.3	15.7	15.7	17.6
16.	16.6	15.9	15.9	17.8
2	16.8	16.1	16.1	18.
4	17.	16.3	16.3	18.2
6	17.2	16.5	16.5	18.4
8	17.4	16.6	16.7	18.7
17.	17.6	16.8	16.9	18.9
2	17.8	17.	17.1	19.1
4	18.	17.2	17.3	19.3
6	18.2	17.4	17.5	19.6
8	18.4	17.6	17.7	19.8
18.	18.6	17.8	17.9	20.
19.	19.7	18.8	18.9	21.1
20.	20.7	19.8	19.9	22.2

The legal denier basis is a skein of silk 450 meters in length weighed by a unit of five centigrams (called denier), or 0.05 of a gram.

The Old Milan denier basis is a skein of silk 476 meters in length weighing 0.0511 of a gram.

The Old Turin denier basis is a skein 476 meters in length weighing 0.05336 of a gram.

The Old Lyons denier basis is a skein 476 meters long weighing 0.05311 of a gram.

The New Lyons denier basis is a skein 500 meters long weighing 0.05311 of a gram.

The International denier basis is a skein 500 meters long weighing 0.05 of a gram.

Therefore, 100 legal deniers equal 103.501 Old Milan deniers; or 99.117 Old Turin deniers; or 99.583 Old Lyons deniers; or 111.111 International deniers.

To find the equivalent of a 14-Legal denier silk in a 14-Old Turin denier silk, multiply 14 by .99117 =13.87638.

SPUN SILK

English System.

This is the same as the English Cotton System, except that the folded yarns are numbered as found instead of on the basis of the single.

Continental System.

The size is the number of 1,000-meter skeins in one kilogram. Folded yarns are numbered on the single yarn.

SILK NOIL YARN

Cut System.

The size is the number of "cuts" of 300 yards in one pound.

ARTIFICIAL SILK

Legal Denier System. The same as natural silk.

TABLE XVI

LENGTHS OF YARDS OF SILK TO THE POUND IN SIZES 9/11 TO 16/18 DENIERS, TAKING THE AVERAGE OF THE SIZE

Explanation: 1. The table gives the raw silk yards to the pound.
2. If thrown unsoaked, the silk is shortened about three per cent., depending on the varying twists and threads.
3. The difference between the raw and thrown silk boil-off, when added to this three per cent., indicates the number of the table to be used up to ten.
Illustration on page 21.

	RAW	(3) Thrown 3% Shortening	(4) 3% Shortening + 1% Soap	
16/18-16½ to 17½	255,100 to 270,600	247,400 to 262,500	244,900 to 259,800	16/18-16½ to 17½
15/17-15½ to 16½	270,600 to 288,000	262,500 to 279,400	259,800 to 276,500	15/17-15½ to 16½
14/16-14½ to 15½	288,000 to 307,900	279,400 to 298,700	276,500 to 295,600	14/16-14½ to 15½
13/15-13½ to 14½	307,900 to 330,700	298,700 to 320,800	295,600 to 317,500	13/15-13½ to 14½
12/14-12½ to 13½	330,700 to 357,100	320,800 to 346,400	317,500 to 342,800	12/14-12½ to 13½
11/13-11½ to 12½	357,100 to 388,200	346,400 to 376,600	342,800 to 372,700	11/13-11½ to 12½
10/12-10½ to 11½	388,200 to 425,200	376,600 to 412,400	372,700 to 408,200	10/12-10½ to 11½
9/11- 9½ to 10½	425,200 to 469,900	412,400 to 455,800	408,200 to 451,100	9/11- 9½ to 10½
	(5) 3% Shortening + 2% Soap	(6) 3% Shortening + 3% Soap	(7) 3% Shortening + 4% Soap	
16/18-16½ to 17½	242,300 to 257,100	239,800 to 254,400	237,200 to 251,700	16/18-16½ to 17½
15/17-15½ to 16½	257,100 to 273,600	254,400 to 270,700	251,700 to 267,800	15/17-15½ to 16½
14/16-14½ to 15½	273,600 to 292,500	270,700 to 289,400	267,800 to 286,300	14/16-14½ to 15½
13/15-13½ to 14½	292,500 to 314,200	289,400 to 310,900	286,300 to 307,600	13/15-13½ to 14½
12/14-12½ to 13½	314,200 to 339,200	310,900 to 335,700	307,600 to 332,100	12/14-12½ to 13½
11/13-11½ to 12½	339,200 to 368,800	335,700 to 364,900	332,100 to 361,000	11/13-11½ to 12½
10/12-10½ to 11½	368,800 to 403,900	364,900 to 399,700	361,000 to 395,400	10/12-10½ to 11½
9/11- 9½ to 10½	403,900 to 446,400	399,700 to 441,700	395,400 to 437,000	9/11- 9½ to 10½
	(8) 3% Shortening + 5% Soap	(9) 3% Shortening + 6% Soap	(10) 3% Shortening + 7% Soap	
16/18-16½ to 17½	234,700 to 249,000	232,100 to 246,200	229,600 to 243,500	16/18-16½ to 17½
15/17-15½ to 16½	249,000 to 265,000	246,200 to 262,000	243,500 to 259,200	15/17-15½ to 16½
14/16-14½ to 15½	265,000 to 283,300	262,000 to 280,200	259,200 to 277,100	14/16-14½ to 15½
13/15-13½ to 14½	283,300 to 304,200	280,200 to 300,900	277,100 to 297,600	13/15-13½ to 14½
12/14-12½ to 13½	304,200 to 328,500	300,900 to 325,000	297,600 to 321,400	12/14-12½ to 13½
11/13-11½ to 12½	328,500 to 357,100	325,000 to 353,300	321,400 to 349,400	11/13-11½ to 12½
10/12-10½ to 11½	357,100 to 391,200	353,300 to 386,900	349,400 to 382,700	10/12-10½ to 11½
9/11- 9½ to 10½	391,200 to 432,300	386,900 to 427,600	382,700 to 423,000	9/11- 9½ to 10½

COTTON

English Cotton Count.

The count is the number of 840-yard hanks in a pound avoirdupois. Folded yarns are numbered on the single yarns from which they are spun.

Continental System.

The count is the number of 1,000-meter hanks in one-half kilogram. Folded yarns are numbered on the singles from which they are spun.

WORSTED

English Worsted Count.

The count is the number of 560-yard hanks in one pound. Folded yarns are numbered on the single yarn from which they are spun.

Continental System.

The count is the number of 1,000-meter hanks in one kilogram. Folded yarns are numbered on the single yarn from which they are spun.

WOOLEN

Skein.

Yorkshire Count.

The count is the number of 256-yard hanks in a pound, or the number of yards weighing one dram.

Galashiels Count.

The count is the number of 300-yard "cuts" or hanks in 24 ounces, or its equivalent, the number of 200-yard "cuts" or hanks in a pound.

West of England Count.

The count is the number of 320-yard hanks in a pound or the number of 20-yard hanks in an ounce.

American Systems.

Grain count. The count is the weight of 20-yard skein in grains run count (New England). The count is the number of 1,600-yard hanks in a pound or the weight of 100-yard in ounces. Cut count (Philadelphia). The count is the number of 300-yard "cuts" or hanks in a pound.

LINEN AND HEMP

English Count.

The count is the number of 300-yard hanks or less in a pound. Folded yarns are numbered on the single yarn from which they are spun. A spindle of linen is 14,400 yards. A bundle of linen is 200 leas, equal to 60,000 yards.

Continental Count.

The count is the number of 1,000-meter hanks in one-half kilogram.

JUTE AND HEAVY FLAXES AND HEMP

Dundee Jute Count.

The number is the weight of a spindle, 14,400 yards in a pound.

THE DIAMETERS OF THREADS OF DIFFERENT COUNTS

Ashenhurst's Tables

TABLE XVII

COTTON YARNS FROM 200's TO 1's

Counts	No. in One Inch	Counts	No. in One Inch	Counts	No. in One Inch	Counts	No. in One Inch
200	370	80	234	34	152	13	$94\frac{1}{3}$
190	361	75	226	32	148	12	$90\frac{1}{2}$
180	351	70	219	30	143	11	87
170	341	65	211	28	138	10	83
160	331	60	202	26	133	9	79
150	320	55	194	24	128	8	74
140	309	50	185	22	123	7	69
130	297	48	181	20	118	6	64
120	285	46	177	19	114	5	$58\frac{1}{2}$
110	274	44	173	18	111	4	$52\frac{1}{3}$
100	261	42	170	17	108	3	$45\frac{1}{3}$
95	255	40	165	16	$104\frac{1}{2}$	2	$36\frac{1}{2}$
90	248	38	162	15	101	1	$26\frac{3}{20}$
85	241	36	157	14	98	..	...

TABLE XVIII

SHOWING THE RELATIVE DIAMETERS OF WORSTED YARNS FROM 120's TO 1's

Counts	No. in One Inch	Counts	No. in One Inch	Counts	No. in One Inch	Counts	No. in One Inch
120	234	58	163	32	120	13	77
115	229	56	160	30	117	12	74
110	224	54	157	28	113	11	71
105	219	52	154	26	109	10	67
100	213	50	151	24	104	9	64
95	208	48	148	22	100	8	60
90	202	46	145	20	95	7	56
85	197	44	141	19	93	6	52
80	191	42	138	18	90	5	48
75	185	40	135	17	88	4	$42\frac{2}{3}$
70	179	38	131	16	85	3	37
65	172	36	128	15	83	2	30
60	165	34	124	14	80	1	$21\frac{1}{3}$

RAMIE

English Count.

The count is the number of 300-yard hanks in a pound.

Continental Count.

The count is the number of 1,000-meter hanks in one kilogram.

MOHAIR AND CAMEL'S HAIR

Same as the systems for worsted.

In calculating the structure of a fabric and estimating the amount which can be produced from a given quantity of yarn of a given count it is often desirable to know the diameter of the threads. The first systematic attempt to furnish such information was made, as far as we have been able to find, by Prof. Thos. R. Ashenhurst, of the Bradford Technical College.[1] In reference to the accuracy of these values, Professor Ashenhurst makes the following comment: "Although the tables given here have been made with considerable care, and as the direct result of actual observation, there is a possibility of their being slightly inaccurate, so far as the first measurement is concerned, in any one of the materials given, but in all probability this inaccuracy will be such as not in the slightest degree to affect their value for practical purposes, in fact, every care has been taken to make them as reliable as possible in their application to practice. The diameters are given in figures which represent the number that would lie side by side in one inch."

Rosenzweig, in Serivalor, gives the diameter of the silk threads as determined from their specific weight: "The diameter of homogeneous cylindrical bodies is proportional to the square root of their weight." However, as the raw thread is not homogeneous, but a bundle of almost cylindrical bodies, allowance was made in computing the following table:

L. Vignon, in the volume 1886, 1887, 1888, of the annuals of the "Laboratory Studies of Silks, Lyons," gives also extensive measurements of the diameter of the fibre, which closely verify Rosenzweig's measurements. On sizes of twenty to twenty-five deniers, the diameters given in the table were calculated from the rule that theoretically the denier count or weight is proportional to the area of the cross section, which in turn is proportional to the square of the diameter. If, for example, an eight-denier thread is forty-two microns in diameter, then the diameter of a thirty-denier thread is 81.3 microns, thus:

$$8:30: \; : \; (42 \times 42) \; : \; (81.3 \times 81.3)$$

[1] "A Treatise of Textile Calculations and the Structure of Fabrics," fifth edition, 1902, published by G. Broadbent & Co., High St., Huddersfield, England.

DIAMETER OF SILK THREADS FROM 8 TO 54 DENIERS

Deniers	Microns	Inches	No. in 1"
8	42	0.00165	605
9	44	0.00174	570
10	47	0.00183	540
11	49	0.00192	516
12	51	0.00201	494
13	53	0.00209	475
14	55	0.00217	457
15	57	0.00225	442
16	59	0.00232	428
17	61	0.00239	415
18	63	0.00246	403
19	64	0.00253	393
20	66	0.00259	383
21	68	0.00267	374
22	70	0.00272	365
23	71	0.00278	357
24	73	0.00284	349
25	74	0.00290	342
26	76	0.00296	335
27	77	0.00301	329
28	79	0.00307	323
29	80	0.00312	318
30	81	0.00317	312
31	83	0.00323	306
32	84	0.00328	302
33	85	0.00333	299
34	86	0.00338	295
35	87	0.00343	292
36	89	0.00350	285
37	90	0.00355	282
38	91	0.00359	279
39	92	0.00362	276
40	93	0.00366	273
41	94	0.00370	270
42	95	0.00374	267
43	96	0.00378	264
44	98	0.00386	259
45	99	0.00390	256
46	100	0.00394	254
47	101	0.00401	252
48	102	0.00402	249
49	103	0.00405	246
50	105	0.00414	241
51	106	0.00418	239
52	107	0.00422	237
53	108	0.00425	235
54	109.1	0.00429	233

One Micron is .001 millimeters, or 0.0000394 inches.
One Millimeter equals 0.03937 inches. 25,450 Microns equals one inch.

CONDITIONS CAUSING VARIATION IN SIZE

On Raw Silk

First. The standard method of taking the average of thirty sizing test skeins is subject to a variation of from one to ten per cent, depending on the evenness of the silk. For this reason Rosenzweig measures 90,000 meters, ten averages of one hundred sizings and the United States Testing Company recommends for average size twenty test skeins of 4,500 meters each, a total of 90,000 meters, known as the compound sizing test. This test should not be used for judging the uniformity of silk.

Second. The moisture in the raw thread may vary as much as thirty per cent, on thrown silk as much as five per cent.

On Thrown Silk

Third. The breaking out of the fine threads causes the thread to become heavier in proportion to the length. Assuming that the fine threads breaking out average seven denier, and that they average sixty yards, we have the following increase in size on a 13/15 denier silk:

Breaks Due to Fine Ends	Denier Increase in Size
20	.16
30	.205
40	.25
50	.30
60	.35
70	.39
80	.44
90	.48
100	.53
110	.57
120	.62
130	.66
140	.71
150	.75
160	.80

Fourth. The gain in soaking.

Fifth. The shortening of the thread due to spinning and twisting. This under a normal tension is about one per cent on a two thread 16/14 turns organzine; about 4.8 per cent on a two-thread 50/44 turn grenadine.

Sixth. The tension in first spinning may stretch the thread ten per cent, depending on the process.

Yarn Count Conversion Factors

The Textile Recorder, August, 1912, contained a table computed by Watson, by which if the length is known in yards and the weight in grains, the count can be computed for any of the systems given.

Table XI

Material	System	Weight in Grains of 1 Yard of 1's Yarn
All Yarns	Metric	14.11
Worsted	Continental	14.11
Worsted	English, American	12.5
Worsted	French (Roubaix)	9.93
Worsted	French (Fournies)	4.97
Spun Silk	French, Swiss	14.11
Spun Silk	English, German, American	8.33
Cotton	English, German, Swiss, American	8.33
Cotton	French	7.05
Linen, Hemp	Almost Universal	23.33
Ramie	English	23.33
Ramie	Continental	14.11
Woolen	Yorkshire Skeins	27.34
Woolen	West of England	21.87
Woolen	American Run	4.375
Woolen	German	4.81
Woolen	Belgian, French (Sedan)	4.72
Woolen	French (Elbeuf)	1.96
Raw Silk	Ounce System	437.5

Rule for Table XI. Divide the number of yards in the sample by its weight in grains and multiply the quotient by the factor given in the table.

Table XII

Material	System	No. of Yards of 1's Yarn Which Weigh 1 Grain
Raw Silk	Dram System	365
Raw Silk	Denier System	634
Woolen	American Grain	20

Rule for Table XII. Divide the weight of the sample in grains by its length in yards and multiply the quotient by the factor given in the table.

To convert—

English worsted to metric worsted divide by 0.886
English cotton to metric cotton divide by 1.18
English spun silk to metric spun silk multiply by 1.694
Drams per 1,000 yards to deniers per 450 meters multiply by 17.44
Deniers per 450 meters to drams per 1,000 yards divide by 17.44

PART II—CHAPTER VI

METHOD OF MEASURING AND CLASSIFYING RAW SILK AS USED AND PARTLY DEVELOPED BY THE AUTHOR

Winding Test

A true winding test can only be made by counting the breaks on the whole skein from start to finish. As Japan skeins at 167 thread speed run from four to five hours, it takes too long a time to make a test on the whole skein and a shorter test becomes necessary. After working several methods for a number of years I found that any short method that would be true to the breaks on the whole skein within a maximum variation of fifteen per cent would be close enough for a winding test. I then made a series of twenty tests on Japan, single and double skeins, Italians, Chinas and Cantons, and from this series found the following method came within the fifteen per cent maximum limit; the series did not vary more than five per cent.

Air Condition—Temperature seventy to seventy-five per cent at seventy to seventy-five per cent Relative Humidity.

First—Select twenty skeins from one bale. We must make our selection from original packages, that is one bale. Whilst most of us buy in five and ten bale lots, the bales are not always alike. A bale, however, generally represents the product of one filature, which is not always true of a five or ten bale lot. I have found twenty skeins necessary to represent the average conditions of a bale and give results equal to tests made on sixty skeins. I found ten skein tests varying too much.

Rub Gums

Gums or reel markings must be rubbed out before winding. On hard gums they can be daubed with a warm emulsion which softens the gums so they can be thoroughly removed.

Skeining or Dandering

Skeins up ten skeins with under side up, the other ten regular.

Speed

Rated when test is half completed.

On unsoaked silk and soaked below thirteen deniers, 120 yards per minute.

On soaked silk over thirteen deniers, 180 yards per minute.

Swifts

Twelve stick, Pin Hub unweighted.

Method of Making Test

Make a starting run of fifteen minutes, don't count breaks, then wind 300,000 yards counting breaks.

At 120 thread speed, Run 125 minutes.
At 180 thread speed, Run 84 minutes.

The sum of all the breaks on the 300,000 yards equals winding count.

(For waste and cost tables add eight to count for first end tied up which is the equivalent of the twenty first ends tied up on the 300,000 yards wound.)

The breaks the first half hour are very excessive at times. Break tests made only on the first hour winding sometimes vary as much as one hundred per cent. When making a starting run of but six minutes you still get too many breaks; tests covering many years show that fifteen minutes for a starting run are required to give results representing the actual conditions of bale.

To change the count to approximate breaks per skein on 14/16 denier size divide by six.

Method of Measuring Strength or Tenacity

Relative humidity should be maintained between sixty-five to seventy per cent at a temperature of seventy to seventy-five degrees F.

Select twenty skeins from different parts of a bale and reel twenty-two and one-half meters from each of the twenty skeins, making a full length sizing skein of 450 meters. Weigh this carefully in deniers and use it as the average size of thread. Cut this skein in two and draw out thirty threads from different parts of the skeins, making the tenacity test on a standard serimeter in the usual manner. To find the relative value, apply strength table or multiply the average size by four and divide this result into the average tenacity, multiplied by 100, shown by test, e. g., Size 14; Tenacity 56; thus.

$$14 \times 4 = \frac{56 \times 100}{56} = 100\%$$

As this test is made for the physical qualities of the thread, not the structural, we must avoid all threads having structural defects in this test.

Measurement of Cohesion

Even though in the loom we find that it is the friction of the harness and reed on the thread and that of the thread upon itself as the shed opens and closes that causes the thread to open and fibres split off, yet extensive experiments show that we cannot measure cohesion by friction because of the rough character of some silk threads due, I am told, to reeling the thread from cocoons that have been softened in water containing sand and limestone salts. Also there are threads which are so tightly agglutinated that they rub through before opening; still others are so smooth and silky that they resist opening by friction a long time and give very untrue relative results when compared with actual working qualities.

The method of testing resorted to commonly is to separate the fibres of the thread between the thumb and forefinger, noting such results as this crude pro-

Winding Table

Waste 13/15 Den.

Count	No. Swifts Run	Amer. Reel	St-Canton Reels	Class
18/20	114	0.30%	....	Very well
21/22	110	0.33	....	....
23/24	105	0.36	....	....
25/26	100	0.39	....	....
27/28	94	0.42	....	....
29/30	90	0.45	....	....
31/32	86	0.48	....	Very well
33/34	82	0.51	....	Well
35/36	78	0.54	....	Well
37/38	75	0.57	....	Well
39/42	72	0.63	....	Well
43/46	66	0.69	....	Well
47/50	62	0.75	....	Fair
51/54	58	0.81	....	Fair
55/58	54	0.87	....	Fair
59/62	52	0.93	....	Fair
63/66	50	0.99	.....	Only fair
67/70	47	1.05	.....	Only fair
71/74	44	1.11	....	Only fair
75/78	42	1.17	....	Poor
79/82	40	1.23	1.80%	Poor
83/86	39	1.29	1.84	Poor
87/90	37	1.35	1.95	Poor
91/94	36	1.41	2.06	Very poor
95/98	35	1.47	2.15	Very poor
99/102	33	1.53	2.24	Very poor
103/106	32	1.59	2.33	Well for Canton
107/110	31	1.65	2.42	Well for Canton
111/114	30	1.68	2.50	Well for Canton
115/118	29	1.74	2.59	Fair for Canton
119/130	28	1.87	2.86	Fair for Canton
131/140	27	1.92	3.08	Fair for Canton
141/150	26	2.17	3.33	Fair for Canton
151/160	25	2.32	3.52	Poor for Canton
161/170	24	2.47	3.74	Poor for Canton
171/180	23	2.62	3.96	Poor for Canton
181/190	22	2.77	4.18	Poor for Canton
191/200	20	2.92	4.20	Very poor for Canton
201/210	19	3.07	4.50	....

For further information on Winding see Chapter IV; also tentative recommendations of the Raw Silk Classification Committee in the Appendix, Part VI.

cedure may make manifest, the personal equation rendering the thumb and forefinger test, at best, no more than a means for arriving at approximate results, which, although better than nothing, are not capable of tabulation and comparison when secured by the efforts of different operators, or even by the efforts of the same operator, working at different times or under different conditions.

In view of the foregoing, it is the object of this invention to provide a simple but efficient machine whereby cohesion tests on silk thread may be carried out readily, and whereby the results of the tests will be of such a conclusive and uniform nature that they may be compared, thereby producing a standard for cohesion tests.

Experiments covering several years show that cohesion can be measured by rolling the thread under pressure. I then followed the rule of physicists and measured its relative order, fixed an arbitrary scale of relative values. The

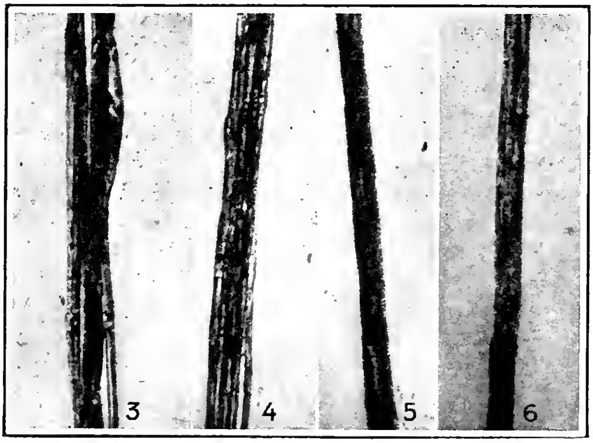
Strength or Tenacity Table

Class	%	DENIERS																	
		11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	106	47	51	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116
	105																		
Very	104																		
Good	103																		
	102																		
	101																		
	100	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112
	99																		
	98																		
	97																		
	95																		
	93	41	45	49	53	57	61	65	67	71	75	79	82	86	90	94	98	101	105
	92																		
Good	91																		
	89																		
	87																		
	86	39	42	45	49	53	57	61	63	67	70	74	77	81	84	88	91	94	98
	85																		
	84																		
Fair	83																		
	81																		
	80	35	38	41	44	48	52	56	59	62	65	69	72	75	78	82	86	88	91
Only	78																		
Fair	77																		
	76																		
	74																		
	73	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84
	71																		
	70																		
Poor	69																		
	67																		
	66	29	32	34	37	40	43	46	49	52	55	58	60	63	67	69	71	74	77
	65																		
Very	64																		
Poor	63																		
	61																		
	60	27	30	32	35	37	40	42	45	47	50	53	55	58	60	62	65	67	70

number of strokes required to roll open the thread constitutes the unit of cohesion. The test is made on 200 threads, ten threads from each of twenty skeins. See Fig. 22 for cohesion machine. Reeled threads requiring but 286 strokes to open showed an open condition of the thread under a magnification of about 150 diameters like Fig. 3.

509 strokes see Fig. 4
827 strokes see Fig. 5
1612 strokes see Fig. 6

It appears that when the threads have a cohesion over 800 strokes then they are so tightly agglutinated that no voids or openings appear.



Figs. 3, 4, 5, 6.

Rules for Operating Cohesion Machine Speed

The speed is to be 108 strokes (full stroke back and forth) per minute. Five strokes more or less will not affect the results.

Oiling

The roller must be kept oiled at its V shaped bearing. Care must be taken not to get oil on roll. It should spin around freely when moved with the finger. In the worm gear casing use a mixture of fifty-fifty cylinder and machine oil; keep it about three-quarters full. Oil slide and reciprocating motion about once a week.

Adjusting Roll

The roll must be level and roll evenly on the mirror; care must be taken in adjusting it so as not to bind the roller and retard its movement. This can be tested by moving the roller with the finger and seeing if it spins around freely. The roller must bear uniformly on card the full length of stroke and full width of card. This can be tested by running the machine on a blank card and observing whether the polished place on card, when rolled, is of the same brightness. Use paper liners under card carrier lever.

Care of Roller

It is absolutely necessary that the roller be kept free from dust, scum, rust, oil, perspiration and free moisture. Before using the machine clean off roller with a piece of chalk and wipe off with a dry rag.

Black Cards or Mirrors

Use a good quality of hard black cardboard and avoid using a grade that varies very much in thickness or in its hardness. Soft cardboard retards the opening of threads about two to three per cent. Use grade like sample shipped with machine.

Preparation of Mirrors

Use an ordinary sizing reel upon which reel, with a spacing of about sixty threads to the inch, ten threads from each of five skeins or a total of fifty threads to a card. Place the mirror under the threads, then paste a gummed label on each end of mirror, gluing down the threads firmly onto the mirror. Make four cards for each test or 200 threads all told.

Operation of Cohesion Test

Fasten one mirror firmly on each cohesion machine, start same and then place threads on roller. If the thread opens up with two or three scratches with the nail of thumb then the card should be examined after the first hundred strokes and every fifty strokes thereafter until all of the threads are opened the full length of the stroke. If it takes six to nine scratches to open the thread, then the machines may be run about 1000 strokes before the cards need be examined. When the threads once start to open then the card should be examined every fifty strokes.

To examine the threads swing back mirror carrier on rest, remove mirror, bend same so as to slacken the threads, push in a spatula and bend up against threads and see if all threads are opened the full length of stroke. If not, replace the mirror and continue the test for fifty or more strokes until all the threads are opened the full length of stroke. The number of strokes required to open all the threads fully is the unit of cohesion for that mirror. The unit of cohesion for the test is the average of the four cards representing 200 threads.

Note that we use the maximum of each mirror, not the average, but as we use four cards the average is obtained as the unit of cohesion. To take the average of each card requires more time to make a test and a different table must be used. The relative value would not be any different.

Air Conditions

The test should be conducted at a relative humidity of from sixty-five to seventy per cent at about seventy to seventy-five degrees F. No test should be made when humidity is over seventy-five per cent or under fifty per cent. The lagging effect of a silk thread is such that if the mirrors are put in a small box with sixty-five to seventy-five per cent humidity for one hour then they may be tested under any reasonable temperature without any appreciable difference.

Starting New Machine

In starting a new machine rub roller with chalk and run it on a mirror without threads about four hours so as to remove any grit or corrosion that might have accumulated on roller in transit.

Cohesion Table

Based on the maximum average of four cards of fifty threads each on unsoaked silk.

Strokes	Per Cent	Classification	Application
2200	100		
2100	99	Extra Good Cohesion	Very good for Weaving in gum single
2050	98		
2000	97	Extra Good Lustre	Very Good Organ
1950	96		
1900	95		
1850	94	Very Good Cohesion	Good for Weaving in gum single
1800	93	Very Good Lustre	Very Good Organ
1750	92		
1700	91		
1650	90	Good Cohesion	Good for Weaving gum single
1600	89		
1550	88	Good Lustre	Good Tram
1500	87		
1450	86		
1400	85	Fair Cohesion	Fair Organ
1350	84		
1300	83	Fair Lustre	Good Tram
1250	82		
1200	81		
1150	80	Fair Cohesion	Fair Organ
1100	79		
1050	78	Fair Lustre	Good Tram
1000	77		
950	76		
900	75	Only Fair Cohesion	Poor Organ
850	74		
800	73	Only Fair Lustre	Fair Tram has a tendency to become wavy
750	72		
700	71		

650	70	Poor Cohesion	Very Poor for Organ
600	69		
550	68	Poor Lustre	Boil off carefully
500	67		
450	66		
400	65	Very Poor Cohesion	Has a tendency to get lousy and wavy
350	64		
300	63		
250	62	Very Poor Lustre	Very Poor Tram
200	61		
150	60		

Note: Cohesion over 2200 strokes usually is very high in lustre and hand.

Fig. No. 90, Part IV, shows Seem's Improved Cohesion Machine as now manufactured by the United States Testing Co., Inc. The method of making test is slightly different, which is given in the Appendix, Part IV and VI.

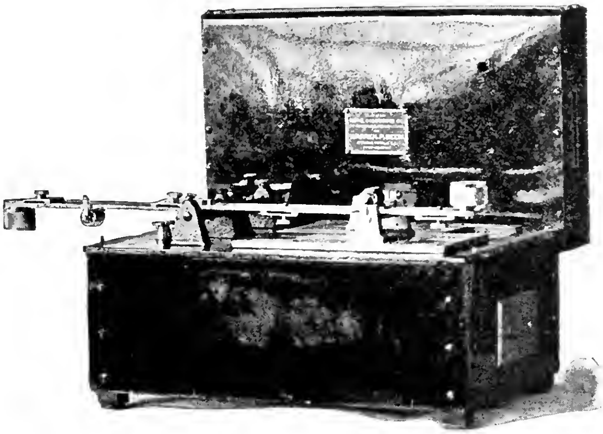


Fig. No. 22—COHESION MACHINE—Patented April 15, 1919

Measurement of Structural Qualities, Evenness and Cleanness

In the measuring and valuing of evenness and cleanness lies the crux of the whole problem of classifying raw silk, either by inspectors or mechanical tests. The difficulty is principally in not taking a sufficient length of thread to give a result that represents the lot. Very fine, fine and coarse threads do not come in regular lengths; the fewer there are the greater the distance apart, the more numerous they are the nearer they come together; therefore, on the higher grades of raw a greater length of thread must be tested to get constant results and a shorter length on the lower grades.

The method developed by the author consists of drawing a thread of raw silk through a steel gauge or cleaner having a V-shaped groove graduated

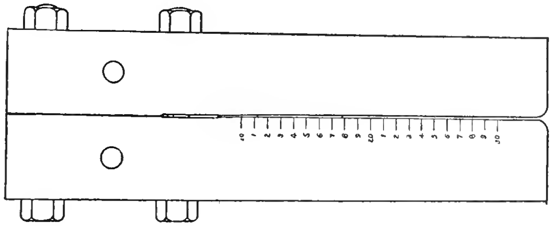


Fig. No. 23—SILK GAUGE.

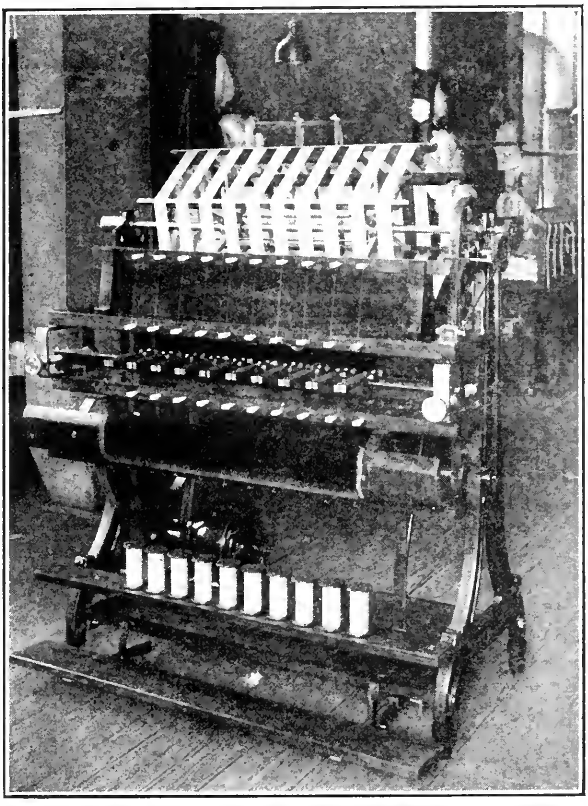


Fig. No. 24—GAUGE REEL FOR DETERMINING EVENNESS AND CLEANNESS OF SILK. (Manufactured by U. S. Testing Co.)

to the average diameter of silk and shown by Fig. 23, and equipped to a measuring reel as shown by Fig. 24.

The gauges are made of a high grade tool steel, graduated, tempered, and then ground absolutely true. The fineness of the gauges is such that the sprains of the metal must be considered and time allowed for this action to subside.

The first gauges were made with blades one-half inch wide, but it was found that there was difficulty in setting them, as they sprung in setting, and when thus set they opened up on the machine. To overcome this they were made with blades one inch wide.

The gauge appears very simple, but there is one condition one must not overlook, and that is that the blades of the cleaner must be one-half inch thick so the long soft slugs do not wriggle through the cleaners: the second difficulty is that as the difference between a thirteen denier and fourteen denier silk is only .00008 inch, it takes an extremely accurate cleaner, and that it is impossible to set it to each size with an ordinary feeler blade, and that feeler blades cannot be manufactured so fine. This problem has, however, been solved with the instrument known as the Silk Gauge, which is two inches wide, six and one-half inches long, and has a range of from eight to thirty deniers and is ground to an accuracy of one ten-thousandth part of an inch.

The gauges are set to a standard size according to the diameter of raw silk as found by Rosenzweig and given in Serivalor, which are as follows:

Deniers	Microns	Inches	Deniers	Microns	Inches
8	42	0.00165	32	84	0.00328
9	44	0.00174	33	85	0.00333
10	47	0.00183	34	86	0.00338
11	49	0.00192	35	87	0.00343
12	51	0.00201	36	89	0.00350
13	53	0.00209	37	90	0.00355
14	55	0.00217	38	91	0.00359
15	57	0.00225	39	92	0.00362
16	59	0.00232	40	93	0.00366
17	61	0.00239	41	94	0.00370
18	63	0.00246	42	95	0.00374
19	64	0.00253	43	96	0.00378
20	66	0.00259	44	98	0.00386
21	68	0.00267	45	99	0.00390
22	70	0.00272	46	100	0.00394
23	71	0.00278	47	101	0.00401
24	73	0.00284	48	102	0.00402
25	74	0.00290	49	103	0.00405
26	76	0.00296	50	105	0.00414
27	77	0.00301	51	106	0.00418
28	79	0.00307	52	107	0.00422
29	80	0.00312	53	108	0.00425
30	81	0.00317	54	109	0.00429
31	83	0.00323			

One Micron is .001 millimeter or 0.0000394 inches.

One Millimeter equals 0.039337 inches.

One can readily understand how coarse sizes choke up in the gauges and break down the thread, but as to the fine and very fine, it generally requires a practical demonstration to convince testers that they actually do catch the fine threads. A fine thread is the result of allowing one or more cocoons to run out; then when two or more cocoon fibres are added, by a cast on the running thread, the diameter is increased beyond the average size of the raw which catches and breaks down the thread; as fine threads are due to carelessness of the reeler, that same carelessness also causes many other defects, all of which catch and show up the fine-thread. The fine end is not, however, a direct catch of the gauges, as other defects, but must be looked for on the reel or take-up side of gauge.

Originally it was planned to determine the number of fine threads by putting an adjustable tension on the paying-off bobbin, regulating it according to the size of the thread, but this was found unnecessary, as the per cent of fine threads not recorded in a test was under two per cent; besides as the tester does not tie out all the fine but just enough to get a thread strong enough to tie up to, there was a question of doubt even as to the two per cent error shown.

This method is to provide a mechanical inspection test to substitute the inspection of mirrors and overcome the confusion due to difference in vision and judgment of various inspectors in different parts of the world. Nothing is left to the judgment of the operator, it is wholly automatic in its operations.

For technical purposes one can run the thread at a finer gauge number and increase the tension to any desired extent, and catch many more minute defects, as the thread flattens out and permits the use of a finer gauge number. For practical and classification purposes this is unnecessary as already explained.

The following comparative test was conducted to prove the merits of the gauge:

Ten bobbins of 200 yards each (total 2,000 yards), were run through the gauges and the length of each fine and coarse thread found was measured. See results shown on Chart 25.

This result was compared with a serimeter break test made on 2,000 yards reeled from the same ten bobbins, each thread one and one-fifth yards long, a half sizing skein was made and cut once, and 200 threads tested from each skein. See results on Chart 26. Chart 25 shows the number and length of the very fine, fine, coarse and very coarse found on each bobbin. On bobbin No. 1 you will note that it had no very fine or fine, but one thread of coarse ten yards long and three threads of very coarse, two of five yards each and one of nine yards, or a total of nineteen yards. A summary of the test shows the following:

Very fine	27 yards
Fine	172 yards
Coarse	105 yards
Very coarse	262 yards
Total	566 yards

The length varied from two to ninety-three yards or an average of thirteen yards. Chart 26 shows one thread breaking under six deniers, five threads between seven and ten denier, two threads between eighteen and twenty-one denier, one thread over twenty-one denier, and 191 threads between ten and eighteen denier. The size was determined from the breaking strain by counting the size as one-quarter that of the breaking strain in grams.

The summary of the test shows:

Fine	126 breaks	× 1.21 yards	=	126	yards
Very fine	17 breaks	× 1.21 yards	=	21	yards
Coarse	151 breaks	× 1.21 yards	=	183	yards
Very coarse	98 breaks	× 1.21 yards	=	118	yards
Total				448	yards

It will be observed that there is a difference between the two results of only 118 threads, which on 2,000 threads tested represents a difference on the unevenness of only six per cent, on silk taken from the same bobbins but not identically the same silk.

The sizing test shows an average of 12.9 denier with a range of but five deniers. Bobbin No. 2 shows how the fine and coarse even up and bring the size within 4/10 of a denier of the average.

Chart 25

Ten bobbins of 200 yards each (total 2,000 yards), tested for evenness on gauges, giving number and length in yards of uneven threads found.

Bobbin No.	1		2		3		4		5		6		7		8		9		10	
Class	No.	yds	No.	yds	No.	yds	No.	yds	No.	yds	No.	yds	No.	yds	No.	yds	No.	yds	No.	yds
Very	..	..	1	5	..	..	..	..	..	..	1	12	..	..	..	..	..	..	1	2
Fine	..	..	..	..	..	..	..	..	..	..	1	8	..	..	..	..	..	..	..	..
under	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7 den.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Fine	..	..	1	14	1	5	1	24	..	..	1	6	..	..	1	56	..	..	1	6
7 to 10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
denier	..	..	1	23	..	..	1	21	..	..	1	16	..	..	..	..	..	..	..	..
Coarse	1	10	..	..	..	..	1	4	1	8	1	4	..	..	..	..	1	9	1	26
18 to 21	..	..	..	..	..	..	..	..	..	..	1	8	..	..	..	..	..	..	1	22
denier	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	14
Very	1	5	1	16	..	..	1	93	..	..	1	41	1	5	1	4	1	8	1	4
Coarse	1	5	..	..	..	..	1	10	..	..	1	3	1	3	1	3	1	8	1	3
over 21	1	9	..	..	..	..	1	2	..	..	..	..	..	..	1	3	1	3	1	7
denier	..	..	..	..	..	..	1	5	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	1	22	..	..	..	..	..	..	..	..	..	..	..	..

Total length of uneven threads found, 566 yards.
Average length 13 yards, shortest 2 yards, longest 93 yards.

Chart 26

Evenness test made on ten sizing skeins 225 meters long, cut once and representing 2,000 yards, one and one-fifth yards long. Reeled from the same bobbins as test represented by Chart 25. The size was determined by the breaking strain on serimeter by counting the size as one-quarter that of the breaking strain.

Skeins	1	2	3	4	5	6	7	8	9	10
Very fine under 7 denier	1	2	1	..	5	..	..	..	5	3
Fine between 7 & 10 den...	5	4	5	1	42	4	2	5	24	12
Coarse 18 to 21 denier	2	6	4	46	10	39	39	5	..	..
Very Coarse over 21 denier	1	7	5	23	2	42	15	1	1	1
Normal between 10 & 18 den..	191	181	185	130	141	115	144	189	170	184
Size	12.50	12.50	13.00	15.00	10.50	16.00	15.00	12.50	11.00	11.00

Average size, 12.9 denier.

Total length of uneven threads found, 448 yards.

In making check tests of different operators on the gauge reel for the evenness and cleanness test on raw silk, it was found that on cleanness all operators recorded practically the same number of defects and classed them properly, but on evenness there was some disagreement due partly, as Mr. Edwards explains in Part IV, to the limit of clear, distinct and definite human visibility. The Raw Silk Classification Committee has divided the evenness defects into four classes, viz.:

A. Weak threads (tender or fine) are those which break thirty per cent below average strength of the thread.

B. Very Weak threads (tender or fine) are those which break fifty per cent below the average strength of the thread.

C. Coarse threads are those which catch and break in the gauges and of which the strength is thirty per cent above the average strength of the thread.

D. Very Coarse threads are those which catch and break in the gauges and of which the strength is fifty per cent above the average strength of the thread.

This subdivision agrees, except in two cases, with my practice, given in my pamphlet on the Classification of Raw Silk by Mechanical Means. The exceptions are as follows:

I class the Very Weak (tender or fine) as those breaking at twenty-four grams and under on all sizes of silk. In my pamphlet, I call the Very Weak those that break at twenty-eight grams or under. I reduced this from twenty-eight to twenty-four as more extensive observations, covering throwing, weaving and knitting, show that twenty-four grams represents the breaking strain more often than twenty-eight grams.

All practical mill superintendents and foremen are agreed that it is essential to know how many Very Fine or Very Weak threads are in the silk that will break down in the various operations, as they affect not only the evenness of the fabric, but also the working qualities in each operation. This is true on 11/13 as well as on 20/22 denier silk. Using the rule, one-quarter the breaking strength in grams represents the size of the silk, we find that on an 11/13 denier silk fifty per cent under the average size would equal six deniers x 4 = 24 grams or the breaking limit set for Very Weak threads. On a 20/22 however, fifty per cent under the average, twenty-one denier, equals 10 1/2 x 4 = 42 grams.

One will observe that on the finer sizes fifty per cent under the average size does give the Very Weak threads that break in manufacturing, but on the coarser sizes the Very Weak threads would represent threads breaking at forty-two grams and under, but as no threads break at fifty-two grams and only a very few at thirty grams we see then that, when using the rule of fifty per cent under the average size, we do not get the thread that actually breaks out in mill operations.

To conform to the tentative rules of the Raw Silk Classification Committee, yet not fail to show the number of Very Weak threads that break at twenty-four grams and under, I have divided the evenness into five classes.

Very Fine.	Coarse.
Medium Fine.	Very Coarse.
Fine.	

The Very Fine are those breaking at twenty-four grams and under on all sizes of silk. The Medium Fine are those breaking between twenty-four grams and fifty per cent below the average strength of the thread. The rest of the classes are the same as given by the committee.

To meet the need of a uniform contrivance to classify the evenness quickly and overcome the difference in judgment between different testers, the following chart and scale was devised. Fig. 27 represents a Toledo Oil Plunger Scale equipped with a chart as shown in Fig. 28. A short length of thread is passed twice around the hook on which the weight A hangs and brought together double as shown in Fig. 29. A gradual downward pull is then exerted with the hand on the double threads until the threads break, which causes arm C to swing into one of the colored zones representing the evenness class as shown on the chart; e. g., If arm C swings into the red (No. 1) zone and the thread breaks then it is a Very Weak thread, and breaks under 2×24 grams or forty-eight grams. The Medium Fine on a 13/15 denier breaks between fifty and fifty-six

grams and is represented by the yellow (No. 2) zone. The Fine breaks in the green (No. 3), Normal in the white (No. 4), Coarse in the brown (No. 5), and Very Coarse in the blue (No. 6) zone.

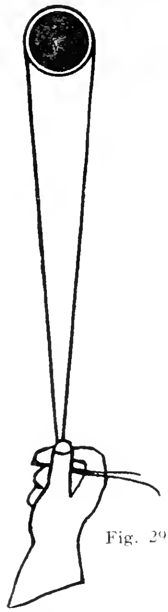


Fig. 29

To the casual observer it may seem superfluous to sub-divide the evenness into five classes and may appear as a complicated arrangement; but to those who are equipped with the scale, it provides a very simple and uniform method that only requires a steady pull on the threads and precaution against a sudden jerk to assure uniform results between different testers. Chart 28 gives the various sub-divisions of the zones in grams.

Chart 28. Breaking Strain in Grams on Double Thread

Deniers	Very fine	Medium fine	Fine	Coarse	Very coarse
10/12	48		50- 62	114-130	132 & over
11/13	48		50- 68	124-142	144 "
12/14	48	50	52- 72	136-154	156 "
13/15	48	50- 56	58- 78	146-166	168 "
14/16	48	50- 60	62- 84	156-178	180 "
15/17	48	50- 64	66- 90	166-190	192 "
16/18	48	50- 68	70- 96	178-202	204 "
18/20	48	50- 76	78-106	196-226	228 "
20/22	48	50- 84	86-118	218-250	252 "
22/24	48	50- 92	94-130	240-274	276 "
24/26	48	50-100	102-140	260-298	300 "
26/28	48	50-108	110-152	280-322	324 "

This table and Scale Fig. 27, calculated on the basis of one-eighth of breaking strain in grams on the double thread represents the size of the single thread. As there are silks that are weak and break at three and a half and in rare cases three times the average size in deniers, single thread, the same scale can be used by adjusting weight D to cause the scale to weigh twelve and a half and twenty-five per cent heavier; e. g., let us say that a fourteen denier silk showed a breaking strain of fifty-six grams, which equals four grams per denier and is the basis on which the scale is computed, but if we test a silk of which the breaking strain is only three and a half times the size, then the breaking strain is $14 \times 3\frac{1}{2}$ or forty-nine grams or twelve and a half per cent weaker; then the scale must be adjusted so that a breaking strain of forty-nine grams actually records fifty-six grams, and then the zones will represent the various classes of evenness accurately.

The committee does not differentiate between the various evenness defects but counts them as found. I still find that the evenness defects—**Very Fine,** (also called very weak) under six denier on 13/15 silk; **Fine** (also called weak), between six and ten deniers; **Coarse,** between eighteen and twenty-two deniers; and **Very Coarse,** over twenty-two deniers, should not be counted as found, but that we should differentiate between the Very Fine and Very Coarse and penalize them.

Let us consider the effect of evenness defects on the following variety of fabrics.

First—When using single thread in the gum for weaving, which is mostly coarse sizes, the very fine break in winding, warping and weaving; some of the very coarse get caught in the reed and also break down. In boiling off, the uneven threads lose their form and become almost one homogeneous mass of fibres, also in heavy cloths they are compressed and show only about one-fourth of the thread on the face. The uneven threads then do not affect the cloth, and in this product we can consider evenness only from a working point of view.

Second—On knitted fabrics evenness is a very important quality, as all the fine threads show light streaks, and the coarse show heavy streaks, regardless of whether the threads are twisted or not. The evening up factor minimizes the effect when using heavy threads. The very fine break down and hinder operations.

Third—On cloth woven from doubled and twisted threads one must first consider the evening up factor, which results when two or more raw threads are doubled together. The higher the number of threads the more even they will become. A coarse thread twists up tighter than a fine or normal thread, and the color becomes duller, and on certain classes of weaves the cloth shows streaked in shade. When doubling a fine and coarse thread together a corkscrew thread forms; when doubling a fine and very coarse thread the corkscrew becomes so marked that large loops form, and these frequently catch and break down in warping and weaving. Corkscrew threads show a spiral effect in the cloth when the warp appears on the surface of the cloth, and such threads are very unsuitable for satins.

Fourth—In throwing, about seventy-five per cent of the very fine threads break down, cause waste and increase labor cost; the fine, when doubled up with the coarse, cause corkscrews; but aside from that, throwing is not affected by unevenness.

Fifth—In weaving heavy cloth like taffetas, unevenness of the thread does not show, but when two fine threads come together, as frequently happens, we get the strength of only a single thread of raw and those often break when operating on fast speed.

These five specific cases show that the very fine are a serious hindrance in every process of throwing and manufacturing, and on all classes named. The fine and coarse threads affect only two, and the very coarse only four of the five specific cases referred to.

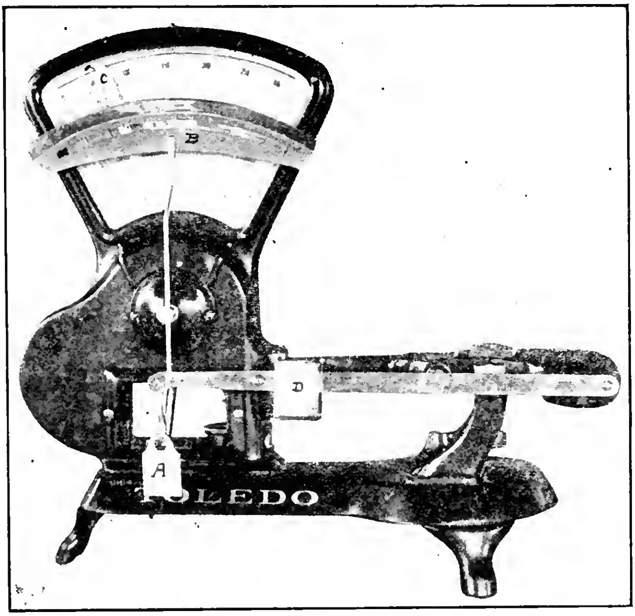


Fig. 27

If we rate evenness by the actual number of defects found, regardless of their kind, then the relative value of evenness will never be true to the real value of the finished fabric or working results. When a defect invariably influences working results and quality of fabric, that defect must bear a direct relation to the purchase price, and the effort required to prevent it, and must be shown on every test and on all sizes of silk. My practice has been to penalize the very fine; first, for the smaller diameter causing a finer size; second, for excessive waste made; third, for additional labor cost; and fourth, for labor trouble;

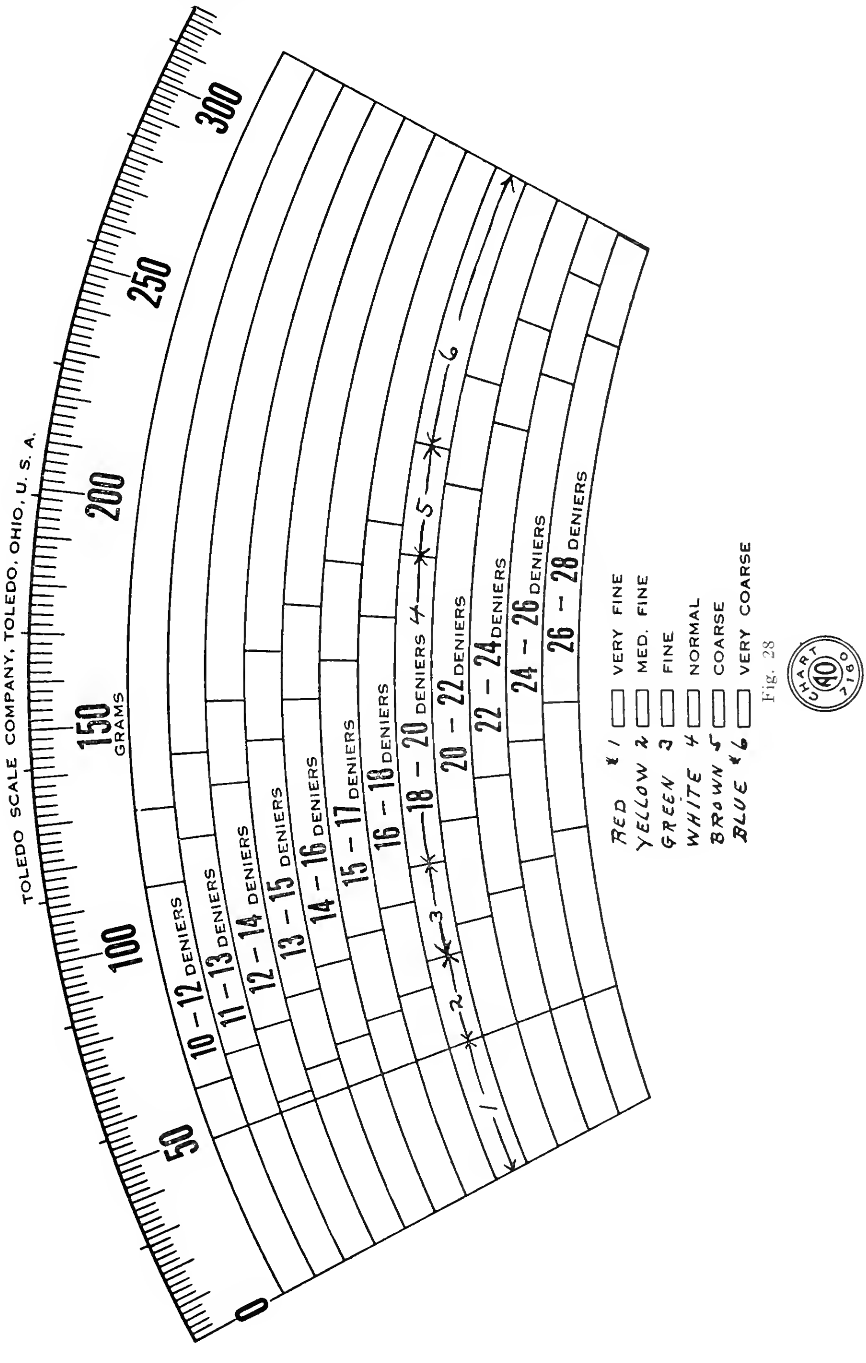

TOLEDO SCALE COMPANY, TOLEDO, OHIO, U. S. A.
0
50
100
150
GRAMS
200
250
300
10 – 12 DENIERS
11 – 13 DENIERS
12 – 14 DENIERS
13 – 15 DENIERS
14 – 16 DENIERS
15 – 17 DENIERS
16 – 18 DENIERS
18 – 20 DENIERS
20 – 22 DENIERS
22 – 24 DENIERS
24 – 26 DENIERS
26 – 28 DENIERS
1
2
3
4
5
6
RED #1 VERY FINE
YELLOW 2 MED. FINE
GREEN 3 FINE
WHITE 4 NORMAL
BROWN 5 COARSE
BLUE #6 VERY COARSE
CHART 40 716

Fig. 28

but in the opinion of Mr. Post four times appeared too high, and we reduced the penalty to three, and the very coarse to two.

If we add them all together without penalizing the very fine and very coarse, then our evenness value will not only be untrue to cost values, but also to unevenness in the fabrics. The quality of finished fabrics is judged by the absence of extremes, and in the case of evenness by the absence of very marked light or heavy streaks. The light streaks are not only more noticeable, but that is also where the cloth first wears out. My experience shows that a true relative value can only be had by penalizing the very fine and very coarse, and then grouping the common value of all the evenness defects.

Method of Measuring Cleanness Defects

The cleanness defects are defined as follows by the Raw Silk Classification Committee:—

On account of the unequal importance of the different cleanness defects in the manufacturing and finishing processes and in their effect upon the quality of the finished goods, cleanness defects are divided into two classes, viz.—Major Defects and Minor Defects.

(A) **Major Defects—**

1. **Waste** is a mass of tangled open fibre attached to the raw silk thread.

2. **Slugs** are thickened places several times the diameter of the thread, of one-eighth inch or over in length.

3. **Bad Casts** are abruptly thickened places on the threads due to the cocoon filament not being properly attached to the thread.

4. **Split Threads** are large loops, loose ends, or open places on the thread where one or more cocoon filaments are separated from the thread.

5. **Very Long Knots** are knots which have loose ends exceeding one-half inch in length.

6. **Cork Screws** are places on the thread where one or more cocoon filaments are longer than the remainder and wrap around the thread in spiral form.

(B) **Minor Defects—**

1. **Nibs** are small thickened places less than one-eighth inch in length.

2. **Loops** are small open places in the thread caused by the excessive length of one or more cocoon filaments.

3. **Long Knots** are knots which have loose ends from one-quarter to one-half inch in length.

4. **Raw Knots** are the necessary knots for tying breaks in the raw silk thread during the reeling and re-reeling operation. The ends of the knot should be less than one-eighth inch long. The number of raw knots should be recorded but they should not be counted among the defects.

I use the description given to determine the various cleanness defects, and in addition I also class **Hairiness,** which consists of small loops about one sixty-fourth inch long which because of their great number look like short hairs standing up on the skein when looking across the face of same. This hairiness shows in

the cloth when the loops appear about 30,000 to 45,000 on 300,000 yards of thread. They do not catch in the gauges, if they did it would be very impractical to count them, even when under 30,000 on 300,000 yards of thread. These are counted on one section of the reel after 150 yards per skein are reeled and increased to 300,000 yard basis. The penalties on hairiness are as follows:—

40,000 to 70,000	5%
70,000 to 200,000	10%
Over 200,000	15%

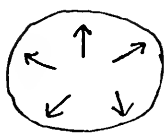
Deduct same from cleanness quality as shown on classification sheet.

The gauges have been condemned by critics because they do not catch these minute defects, also because they say that when the thread runs fine then the smaller defects are not removed as thoroughly as when the thread runs coarse and that a perfect instrument to measure cleanness of the raw silk thread must adjust itself to the variation of the silk thread. Instead of being a fault I find it a distinct advantage. The very worst silk has over a million defects per x yards (300,000). To attempt to count these would be impracticable, besides what benefit would be gained by the knowledge if many thousand of them do not show in the cloth? In counting defects on mirrors no two inspectors would give the same results as the one having the keener sight would find more defects than the one of duller vision. The thread is run through the gauges at the average size of the thread tested which, for example, we will take as fourteen deniers; let us now suppose that the thread becomes ten deniers; theoretically it appears that it will not clean the thread as thoroughly as it did when the thread was running through at fourteen deniers, but we must not forget that the decrease in diameter is not in proportion to the denier count or as 14:10 but in proportion to the area of a cross section which in turn is in proportion to the square of the diameter.

10 deniers = 0.00183 inches
14 deniers = 0.00217 inches

or as we see a ten denier is but fifteen per cent less in diameter than a fourteen denier silk.

Let us look at it another way: if we cut a thread in two and look at a cross section we see that as it increases in size it spreads out in all directions thus



and when it goes through the gauges it exposes but two sides to the gauge and in addition to that is the flattening effect on the thread as it passes through at high speed.

It is quite evident that what we want to know is the relative number of objectionable defects that are on the thread; their size governs this exclusively; therefore, no matter on what size thread they appear the only thing we want to

know is, are they large enough to be classed as objectionable? How are we to determine this? By the sense of vision the result varies with the inspectors. A more definite means is therefore necessary, which has been found in the gauges. These are set to a standard size according to the diameter of raw silk as found by Rosenzweig.

The Amount of Silk Required to Get Constant Results, Duplicate Tests and Represent the Lot

Twenty skeins selected from different books of the bale have been found to represent the bale; when less than that is taken the results are reliable if the rest of the bale is like the sample, but to get the average condition and detect variation, twenty skeins are necessary to a bale. Of course you can fool this by putting in a number of books of very bad silk, but for this the tester must be on guard and when one skein runs very much worse than the others then another set of twenty skeins must be taken from the books that have been omitted in the first selection. To represent the lot two tests out of five, three out of ten and four out of twenty bales are necessary under present conditions to get the average of a lot. When the run of the bales is known then one test will be sufficient.

The fewer the defects the more silk is required to get constant results, as the defects are further apart and consequently a sufficient amount of thread must be used to permit these to average up; the closer the defects the less amount of thread is required. The result of several thousand tests and comparative working results show that when the total number of defects besides raw knots, fine and coarse threads equal 150, then the test can be stopped and the result increased to 300,000 yards by multiplying by the following rule:

20 bobbins	500 yds. ea.	total	10,000	yds.x30	=300,000 yds.
20 bobbins	1000 yds. ea.	total	20,000	yds.x15	=300,000 yds.
20 bobbins	2000 yds. ea.	total	40,000	yds.x 7½	=300,000 yds.
20 bobbins	3000 yds. ea.	total	60,000	yds.x 5	=300,000 yds.

Care must be taken that each test represents the twenty skeins. As the gauge reel is only equipped with ten ends, change bobbins, when test is half finished.

Method of Setting Gauges

According to Rosenzweig, the diameter of raw silk of twelve deniers is .00201 inch and twenty-seven deniers is .00301 inch; the nearest we can get to .002 inch is twelve deniers and .003 inch is twenty-seven deniers, which are the setting points. It is impossible to measure the diameter of a silk thread with a micrometer caliper, as the thread yields or flattens out more or less under the pressure of the micrometer caliper. On account of this flattening out and the great variation on silk of the same size, no correction can be determined upon. The only way we can correctly set the gauges so that the slot in the gauges corresponds to the outside diameter of the silk thread is by feel and to make this as near uniform as possible is was found necessary to use weights. It was also found that by using a feeler blade one-half inch wide the same feel could not be had at the lowest point of the gauge as at the high and also that the measurement was so sensitive that in getting the feel, the gauges, when made with but one-half inch

blades, were opened up. To avoid these errors the feeler blades were then made but three thirty-seconds inch wide and weighted as follows:

.002 = weight 14 grams
.003 = weight 17 grams

The ordinary feeler blades bought on the open market are not accurate enough for this work and they must be selected with a micrometer caliper measuring by ten-thousandth part of an inch. (No. 75 Micrometer Caliper made by Brown & Sharpe Manufacturing Company is used by the inventor of the gauges.)

The gauges are shipped properly set, but if by a mishap they require re-setting, tighten up the rear bolt dead tight, then tighten up the front bolt until the .002 feeler blade holds fast at twelve deniers and the .003 feeler blade at twenty-seven deniers. Draw the feeler up and down in slot until it holds its own weight. First clean out the slot very carefully, getting rid of every particle of dust—remember you are working on a very fine measurement. A good grade of tissue paper I find the best for the purpose. Be careful it does not break off and stick fast in the gauges.

Graduation

The graduations are an arbitrary measurement and based on fifteen equal subdivisions between twelve and twenty-seven deniers. The gauges were made six and one-half inches long so as to make the graduations to cover from eight to thirty deniers.

Operating Gauge Test

Speed of Reel

The speed of the takeup of the reel fly is to be 250 yards per minute.

Care of Gauges

The gauges must be kept absolutely clean and free from rust or scum. Oil daily with a good quality of spindle or clock oil, making sure that the oil has run between the two faces of the gauge blades. Do not permit the gauges to become choked up with waste, as it is possible to force open the gauges slightly if waste is wedged in tightly. When the gauges get choked up with silk thread then use a 1.5 feeler blade to push or pick it out. Put the blade in back of the place you desire to clean out and move it towards the front or open part of gauge. Do not use a bent feeler blade that scratches the gauge.

Method of Making Gauge Test

First—Wind from unsoaked silk about 3,500 yards from each of twenty skeins on twenty bobbins, ten from the under side of skein and ten from the regular side. Take every other bobbin and thread up on the gauge reel. Shift the gauges so they all run at the average size of thread. The operator must constantly watch the threads and stop the reel as soon as a break occurs so as to get the yardage uniform. Every time a thread breaks down examine the thread on reel to see if it is abnormal in size, and if so test it on special scale provided for same as shown by Fig. 27. If the thread is abnormal then the evenness defects as well as the cleanness defects must be recorded. The operator must

bear in mind that he is making a double test. that is, evenness and cleanness. After the test is half completed change bobbins, using the second set of ten.

Classifying Working Results

On account of the unequal importance of the different cleanness defects in the working results and finished product, the Raw Silk Classification Committee has divided them into two classes, namely—Major Defects and Minor Defects.

To conform to the tentative rules of the Committee I have adopted the same, excepting that I have added one more class and subdivided the Major into two classes, Major working defects and other Major defects as shown on Raw Silk Classification form. My reason for adding this class is that considerable confusion now exists between classification and working qualities. Nine persons out of ten think that working qualities represent grade, because high class silk always works well, but on medium class silk it may or may not work well depending on what one uses the silk for, and what the value of each quality is. The number of very fine threads and the Major working defects regulate the working qualities, and if these are few the silk will run well, and if numerous it will run poorly, but as these are influenced by air conditions, speeds, general mill practice, style of machinery and class of help, as well as by the process and class of thread thrown, construction of cloth woven and class of fabric knit, one can only give a method of arriving at working results which must be applied to every class and condition, and make a rule for each specific case. But as many of the conditions are alike, I find about six tables will cover the whole field of practical mill operations. The working quality table given only gives the method of arriving at working results and must be modified to represent each case under consideration.

In gathering information on working results from department forepeople and operatives, I found it often very misleading, because they make their ratings by comparisons, i. e. if they were running a very poor lot and got another running fair they would class the one bad and the other good, or if they had a lot running very well and got one running fair they would class the latter as running poor. It therefore became necessary to make actual break tests to gain exact information.

The physical qualities, strength and cohesion, must also be considered. A thread with a low cohesion opens up too much in soaking and the thread becomes split, or the cocoon fibres split off, run a band on bobbin, and break down the running thread. In weaving the single thread in the gum, the friction causes a great many breaks as explained under cohesion.

On silk having a relative strength of say eighty per cent, an eight denier silk has only the strength of a 6.4 denier silk and a fine thread becomes a very fine and breaks.

Therefore, the working table must be modified by the value of the cohesion and strength values. Excepting on very heavy woven fabrics I find that no allowance need be made on cohesion on silk having over 1,500 strokes and on silk having a strength of over eighty-five per cent. I have found that silk showing only eighty per cent strength affects the spinning and doubling to a marked degree.

These classifications are designed first, to give a true relative value as to quality; second, as to their trading value; third, as to their working qualities, so one can select the cheapest silk suitable for the thread or fabric one desires to produce.

An ideal classification is one in which all qualities of a grade are of the same relative value. As the past has shown this is impossible, and the future does not give promise of producing same, one must become informed of the different values so as to select the silk that will yield the net efficient results. Most of the No. 1 silks reaching our market are of an Extra grade in their physical qualities and this gives the fabric a fairly good hand and lustre and answers the requirements of many classes of threads and fabrics. But when the structural defects, evenness and cleanness, are so numerous that the cost of throwing and manufacturing exceeds the difference of a higher priced silk, then it is apparent that a higher grade silk should be purchased. As this is not always possible, one sometimes is compelled to make the best of what can be purchased, but at all times we should pay a true relative price for what we get and not buy chop only, as is now quite frequently the case with silk thread as Ex. Ex. & Ex.

Evenness Table for All Sizes

The following table gives the revised tables for evenness:

To convert evenness defects to common values, multiply by the following factors:

Very Weak threads	(tender or fine)	× 3
Medium Weak threads	(tender or fine)	× 3
Weak threads	(tender or fine)	× 1
Coarse threads	(tender or fine)	× 1
Very Coarse threads	(tender or fine)	× 2

Common Defects	Per Cent	Common Defects	Per Cent
0	100	288	70
9	99	306	69
18	98	324	68
27	97	342	67
36	96	360	66
45	95	378	65
54	94	396	64
63	93	414	63
72	92	432	62
81	91	450	61
90	90	468	60
99	89	486	59
108	88	504	58
117	87	522	57
126	86	540	56
135	85	558	55
144	84	576	54
153	83	594	53
162	82	612	52
171	81	630	51
180	80	648	50
189	79	666	49
198	78	684	48
207	77	702	47
216	76	720	46
225	75	738	45
234	74	756	44
243	73	774	43
252	72	792	42
270	71	810	41
		828	40

The following is the cleanness table now used by the writer and consists of but one table for all sizes. I have also made a change in the penalty on hairiness and now deduct it from the cleanness quality instead of from all qualities as given in my pamphlet.

40,000 to 70,000.................. 5%
70,000 to 200,000.................10%
Over 200,000 ....15%

Cleanness Table

To convert cleanness defects to common values, multiply by the following factors and apply table for size specified:

Major working defects....as counted
Other Major defects......as counted
Minor defects ....× .10

Common Defects	Per Cent	Common Defects	Per Cent
0	100	486	69
15	99	508	68
30	98	530	67
45	97	552	66
60	96	574	65
75	95	596	64
90	94	618	63
105	93	640	62
120	92	662	61
135	91	684	60
150	90	706	59
165	89	728	58
180	88	750	57
195	87	772	56
210	86	794	55
225	85	816	54
240	84	838	53
255	83	860	52
270	82	882	51
285	81	904	50
300	80	926	49
315	79	948	48
330	78	970	47
345	77	992	46
360	76	1014	45
375	75	1036	44
390	74	1058	43
405	73	1080	42
420	72	1102	41
442	71	1124	40
464	70		

Working Table

Number of Very Fine and Major Working Defects	Working Qualities	Per Cent
60 and Under	Very Well	94% and over
61/90	Well	88/93
91/120	Fair	82/87
121/150	Only Fair	76/81
151/180	Poor	70/75
Over 180	Very Poor	60/69

Shall we classify silk by name, numbered groups or percentage? I present herewith Chart 30 which shows the three methods; first, by name and number the same as the method now in vogue; second, by percentage, and third, exclusively by number. Leo Duran, in his second edition of RAW SILK, says that the American manufacturer classifies by per cent, which is a very accurate method. The latter clause expresses exactly what I find the percentage method does, but as some people take these percentages too literally, I consider it timely to caution the reader that it is impossible to distinguish between say eighty and eighty-one per cent silk in working results and quality of the finished fabric, as the thread varies too much in its physical and structural qualities. The percentage method is only a common means to an end, or in other words, a method of placing in a relative group the combined relative values of the four basic qualities comprising a silk thread.

Let us instance an example using the following tests:
Size 14 denier. Strength 52 grams. Cohesion 1500 strokes. Evenness defects on 300,000 yards:

Very fine (weak) threads	60×3	= Common number	180
Medium fine (weak) threads	15×3	= Common number	45
Fine weak threads	8×1	= Common number	8
Coarse threads	20×1	= Common number	20
Very Coarse threads	30×2	= Common number	60
Total	133		313

Cleanness defects:

Major defects	81×1	= Common number	81
Minor defects	800×1/10	= Common number	80
Total	881		161

The common value of strength by percentage is found as follows:

$$\frac{52 \times 100}{14 \times 4} = 92.8 \text{ call } 98\%.$$

Cohesion we find valued in percentage in column 8 and 10 on Chart 30 as 87%.

The common number of evenness is 313, which according to evenness table column 18 is 69%.

The common number or value of cleanness defects is 161, which according to cleanness table is 89%.

Let us now bring together these values into a final grading by the percentage method.

Physical qualities:

Strength	93%
Cohesion	87%
	180

$\frac{180}{2}$ = Average 90%.

Structural qualities:

Evenness	69%
Cleanness	89%

The average of the physical qualities,

Evenness and cleanness $= \dfrac{90 + 69 + 89}{3} =$ Call 82.6. Call 83%

which according to Chart 30, columns 1—2—3, is a Best No. 1 to Ex. or a No. 4 grade silk.

Let us now classify these qualities into a final grade by the group method and average up the different groups, the same as done by percentage.

The cohesion, 1500 strikes, columns 8 and 10 of Chart 30, = No. 3 Grade Silk.

The average of the physical qualities by group method $= \dfrac{2 + 3}{2} = 2\frac{1}{2}$.

The strength is 52 grams, which by dividing the breaking strain in grams by the size thus, $\dfrac{52}{14} = 3.71$ grams per denier, or according to Column 4, Chart 30, we class it in Group No. 2.

The evenness defects, 313, common number, according to Chart 30, column 18 Group No. 7.

The cleanness defects, 161, common number, according to Chart 30, column 36 Group No. 2.

The average of the three qualities according to the group method,

$$\frac{2.5 + 7 + 2}{3} = 3.83.$$

By the percentage method we get 83%, or according to column 2/3 is rated as Group No. 3.

By the group method we get 3.83, and according to column 2/3, would be about 83%, or just the same.

On this test either method brings the same result if one counts the decimal over half a full grade.

FORM A 406 REV.

RAW SILK CLASSIFICATION

BROOKLYN LABORATORY Nov. 24 1921

LOT NO. Sample MARK -- SELLER Sample BALE NOS. 80192/96

STOCK Japan CHOP Sample GRADE GIVEN Best #1/Ex

SIZE " 13/15

APPEARANCE

COLOR		LUSTRE	HAND OR TOUCH	HAIRYNESS PENALTY	SKEIN	GUMS
WHITE IVORY X CREAM	VERY EVEN EVEN X FAIRLY EVEN UNEVEN VERY UNEVEN	VERY GOOD X GOOD FAIRLY GOOD FAIR POOR VERY POOR	VERY SILKY SILKY X NERVY FIRM STRAWY SPONGY	VERY BAD 15 per cent. BAD 10 per cent GOOD 0	ST. AMERICAN X IMITATION STRAIGHT CROSS OTHERS	SOFT X HARD NARROW BROAD

MEASURABLE QUALITIES ARE BASED ON 300,000 YDS. MADE ON 40,000 YDS.

BALES TESTED 80194

	10M	10M	10M	10M	300,000 Yds.	Evenness	Cleanness
RAW KNOTS	7	4	5	5	(158)		
EVENNESS DEFECTS							
VERY FINE (WEAK) THREADS	-	1	1	1	23	X3 69	
MED. FINE (WEAK) THREADS	1	-	-	-	8	X3 24	
FINE (WEAK) THREADS	2	1	2	1	45	X1 45	
COARSE THREADS	1	2	2	1	38	X1 38	
VERY COARSE THREADS	2	4	4	5	113	X2 226	
MAJOR WORKING DEFECTS							
WASTE	1	-	-	2	23		
VERY LARGE SLUGS							
VERY LONG KNOTS							
VERY LONG LOOPS							
SPLIT THREADS							
OTHER MAJOR DEFECTS							
SMALL SLUGS	2	1	2	2	53		
BAD CASTS					8		

TOTAL MAJOR DEFECTS ON 300,000 YDS.					84		X1 84
MINOR DEFECTS							
NIBS	6	6	6	5	173		
LOOPS	2	2	2	3	68		
LONG KNOTS							
CORK SCREWS	3	2	3	2	75		
TOTAL MINOR DEFECTS ON 300,000 YDS.					316	X 1/10	32
					TOTAL	402	116
					%	64	92

COMPOUND SIZE—AVERAGE DENIER STANDARD SIZE—AVERAGE DENIER 14

TENACITY GRAMS 56 RELATIVE VALUE 100 % COHESION STROKES 1200 RELATIVE VALUE 81 %

RECORD OF OTHER TESTS—WINDING COUNT ON SOAKED SILK 25

WINDING COUNT ON RAW SILK 45

INDICATIONS OF LOUSINESS None

DISPOSITION OF LOT

Accepted W. P. S.

QUALITY SUMMARY OF RELATIVE VALUES

STRENGTH 100 % COHESION 81 % AVERAGE 91 %

EVENNESS 64 %

CLEANNESS % PENALTY % NET CLEANNESS 92 %

QUALITY NUMBER (AVG. ALL QUALITIES) 83 %

QUALITY SCALE BASED ON RELATIVE VALUES

%	GRADE	%	GRADE	%	GRADE	%	GRADE	%	GRADE	%	GRADE	%	GRADE	%	GRADE
100 99 98 97 96	XXX	95 94 93 92	XX	91 90 89 88 87	X	86 85 84 83 82	Best No. 1 to X Extra	81 80 79 78 77	Best No. 1	76 75 74 73 72	No. 1	71 70 69 68 67 66	1 to 1½	65 64 63 62 61 60	No. 2

Chart # 30. Comparative Classification Ratings

By Name, Percent and Number.

1- Grade by Name	Grand XX	XX	X	Best 1 to Ex	Best #1	#1	1 to 1 1/2	#2		
2- Grade by Percent	96	92	87	82	77	72	66	60		
3- Grade by Number	1	2	3	4	5	6	7	8		
4- Strength, Grams per Denier	4	3.875	3.75	3.625	3.50	3.375	3.25	3.00		
5- " By Name	Grand XX	XX	X	Best 1 to Ex	Best #1	#1	1 to 1 1/2	#2		
6- " By Percent	100	97	94	90	87	84	81	75		
7- " By Number	1	2	3	4	5	6	7	8		
8- Cohesion Strokes	1950	1750	1500	1250	1000	700	450	150		
9- " By Name	Grand XX	XX	X	Best 1 to Ex	Best #1	#1	1 to 1 1/2	#2		
10- " By Percent	96	92	87	82	77	72	66	60		
11- " By Number	1	2	3	4	5	6	7	8		
Evenness Defects										
12- Very Fine (Weak) Threads	--	--	7	9	12	14	19	26	34	82
13- Medium Fine(Weak) Threads	--	--	3	5	6	6	9	12	17	22
14- Fine (Weak) Threads	20	50	57	78	100	75	105	132	183	152
15- Coarse Threads	16	22	13	20	17	20	29	38	60	62
16- Very Coarse Threads	--	--	10	14	18	50	71	92	126	151
17- Total Evenness Defects	36	70	90	126	153	165	233	300	420	469
18- Common Number Evenness Defects	36	72	117	162	207	252	360	468	648	828
19- Evenness by Name	Grand XX	XX	X	Best 1 to Ex	Best #1	#1	1 to 1 1/2	#2	--	--
20- " by Percent	96	92	87	82	77	72	66	60	50	40
21- " by Number	1	2	3	4	5	6	7	8	9	10

Cleanness Defects										
Major Working Defects										
22- Waste	10	9	15	21	27	32	43	53	70	88
23- Very Large Slugs	--	5	8	11	14	17	22	27	36	45
24- Very Long Knots	--	4	8	11	14	17	22	27	36	45
25- Very Large Loops	5	10	18	25	32	34	50	62	82	100
26- Split Threads	--	5	8	11	14	17	24	32	42	61
27- Total Working Defects	15	33	57	79	101	121	161	201	266	332
Other Major Defects										
28- Small Slugs	8	34	56	78	100	122	158	195	257	321
29- Bad Caste	--	14	22	30	38	46	52	77	102	128
30- Total Major Defects	23	81	135	187	239	289	381	473	625	781
Minor Defects										
31- Nibs	200	155	225	305	380	476	618	762	1006	1267
32- Loops	150	198	300	414	535	662	864	1070	1412	1785
33- Long Knots	--	12	19	26	34	42	55	69	91	123
34- Corkscrews	20	25	48	86	111	133	175	209	276	255
35- Total Minor Defects	370	390	592	831	1060	1813	1712	2110	8785	3430
36- Common Number Major & Minor Defect	60	120	195	270	345	420	552	684	904	1124
37- Cleanness by Name	Grand XX	XX	X	Best 1 to Ex	Best #1	#1	1 to 1 1/2	#2		
38- " by Percent	96	92	87	82	77	72	66	60	50	40
39- " by Number	1	2	3	4	5	6	7	8	9	10

Let us now take the same number of evenness and cleanness defects, but of different kinds as follows:

Evenness defects:

Very fine	15×3	= Common number	45
Medium fine	10×3	= Common number	30
Fine	80×1	= Common number	80
Coarse	18×1	= Common number	18
Very coarse	10×2	= Common number	20
Total	133		193

By common value = 78% Group No. 5.

Cleanness defects:

Major	240×1	= Common number	240
Minor	$641 \times 1/10$	= Common number	64
Total	881		304

According to common value table = 80%. Group No. 5.

The above classification shows that by differentiating between the evenness values of various evenness defects that the 133 in the first case give an evenness rating of sixty-nine per cent Group No. 7, and in the second case of seventy-eight per cent, Group No. 5.

The cleanness defects 881 in the first case shows a cleanness rating of eighty-nine per cent, Group No. 3, and in the second case of eighty per cent, Group No. 5.

Taking the physical qualities as ninety per cent we have in the second case a classification of $\frac{90 + 78 + 80}{3} = 82.3\%$ or a Best No. 1 to Extra Silk.

It will be observed that the final rating is just about the same, but by referring to the evenness and cleanness rating, it will be seen that the first set of evenness defects are very much worse than the second lot, and that 240 major and 641 minor defects are much worse than 81 major and 800 minor.

If one studies these conditions it will be observed that when differentiating between defects, that a silk classed as a No. 4 grade silk or Best No. 1 Ex., may have a low evenness rating and a good cleanness rating, and yet be up to grade; or it may have a low cleanness rating and a good evenness rating and also be up to grade. If we do not differentiate between the major and minor evenness and cleanness defects then the evenness values will be alike, which a study of the actual defects found will show is not the real situation. The purpose of classifying raw silk is not only to set a standard measurement for trading, but also for the disposition of the silk. As we Americans manufacture a great variety of threads and fabrics we can use in specific classes a thread that is uneven but clean, in other cases one that is unclean but must be fairly even; therefore we see that a true classification rating must show the physical qualities and an evenness and cleanness rating, that can be used in disposing of the silk.

PART II—CHAPTER VII

CLASSIFICATION OF ORGANZINE IN THE GRAY

On account of the great amount of organzine and other finished thread sold on the American market, it appears timely to consider the classification of same. Until there are definite rules adopted for the classification of raw silk, no rules can be given for the classification of thrown silk thread, yet it appears important that this subject be considered in connection with these articles on silk throwing.

In the quality and money value of organzine enter the following conditions:

First: Moisture contents. This is determined by test for conditioned weight.

Second: Absorption of soaking solution. This is determined by test for boil-off, raw and thrown.

Third: Relative strength. This is determined by tenacity test.

Fourth: Evenness. No method as yet adopted.

Fifth: Cleanness. No method as yet adopted.

Sixth: Quality of throwing. We find the following defects in organzine: Singles, Corkscrews, Waste, Long Knots, Slack Twist, Hard Twist, Bad Reeling, Improper Lacing.

The United States Testing Company has covered the first two items throughly and the writer will simply refer to same as given in appendix.

Relative Strength

In spinning the first time twist sixteen turns per inch the thread increases eleven per cent. in strength. On a two-thread the increase would be eleven plus eleven, or twenty-two per cent, but in adding the second time twist, fourteen turns in the opposite direction, part is again lost.

I adopted the basis used in raw silk and take four times the average size as equaling one hundred per cent silk.

As the thread is subject to the following change in throwing, which affects its weight, and therefore its size, we cannot depend on the raw size, but must make a sizing test on the thrown thread by reeling up a sizing skein from an equal amount of fifteen different skeins, cut this once and draw out thirty threads for tenacity test, making the same in the usual way.

Change of Size in Throwing

First. We find the absorption of moisture and soaking emulsions.

Second: The breaking out of fine threads, causing the thread to become heavier in proportion to its length.

Third: The shortening of the thread due to spinning and twisting, which is about one per cent. under normal tension.

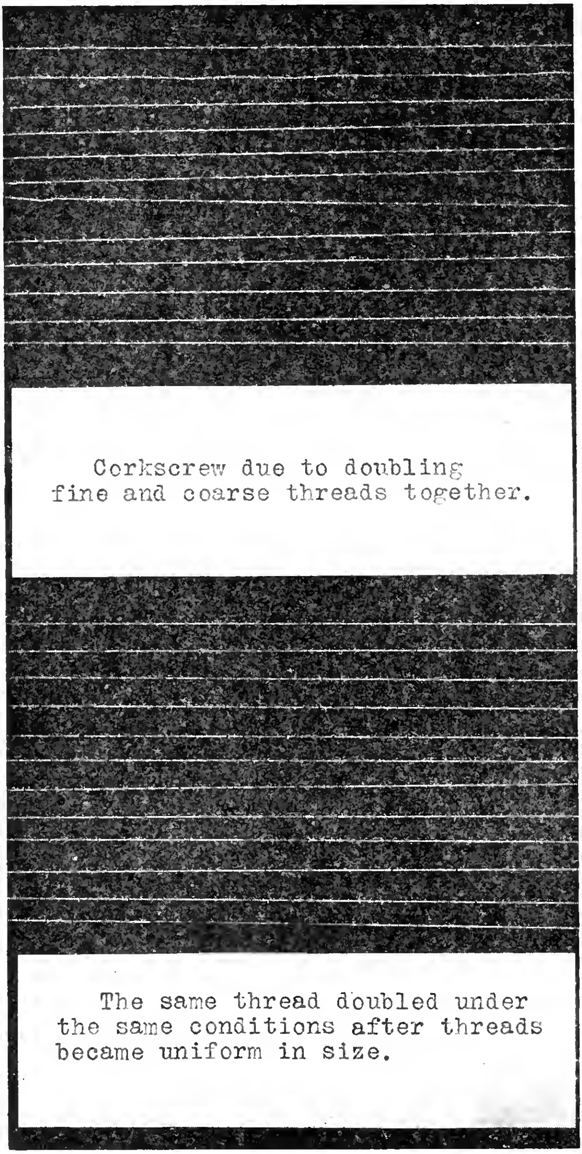

Corkscrew due to doubling fine and coarse threads together.
The same thread doubled under the same conditions after threads became uniform in size.

Fig. 31

Evenness

As the fine and coarse threads even up no conclusions can be drawn from the weight of sizing skeins, but as it has been explained in Chapter III how uneven silk causes corkscrews, we have in this defect the best indication of unevenness, but as corkscrews can also be made by careless doubling we must distinguish between corkscrews made by uneven silk, two thread in the raw, and those caused in throwing. This can be seen by untwisting the thread.

As a corkscrew may be fine and not show in the cloth, when shall we consider it a corkscrew and count it as a defect? I would say that when the twist is pushed back on two inches of the thread and a loop of one sixty-fourth of an inch or larger forms then it should be counted a corkscrew. No method is now known to the writer to determine the number of corkscrews other than to inspect fifteen skeins of 20,000 yards each, and pick one through the skein, counting the corkscrews thread as found. As a corkscrew made by uneven silk will sometimes extend several yards on even silk after the unevenness is passed, we cannot distinguish strictly between corkscrew caused by uneven silk and that caused by imperfect doubling, so that in making a table we must allow a reasonable amount for this, so as to simplify the valuation. See Fig. 31.

The skein should be selected from at least five different bundles of thrown silk. I am not ready, at this time, to submit a table, and each one interested must make for himself a set of tables, using organzine thrown from XX and No. 1 up to grade as a basis and determine by a uniform method how much corkscrew the best and worst contains and make the relative table accordingly, one hundred per cent to represent perfection; seventy per cent the worst condition, making thirty equal divisions between the best and worst.

Cleanness and Throwing Defects

On organzine it is sometimes impossible to determine whether long knots, and waste are raw silk or throwing defects, so we must add the two together and make our table to cover the following defects, giving each one the same value.

Raw silk defects that show in organzine are: Waste, long knots, bad throws and slugs.

Throwing defects: Singles, corkscrews and loops, waste, long knots, slack twist and hard twist.

The best, easiest and quickest way I find to get the above defects slack and hard twist, is to redraw fifteen skeins from a swift, weighted so as to break down a single, through a knife cleaner.

In nearly all breaks the one thread strips back and forms a caterpillar and it is therefore impossible to determine what defect has caused the break, nor is it necessary, as this can be allowed for in table on cleanness and throwing defects.

In this table, due allowance should be made for the cleaning that takes place in throwing a thread and that the grade is raised about one quality in throwing in that respect.

As it has been repeatedly shown that because of the lack of any standard as to what a XX or X raw silk really is in point of evenness and cleanness, it is even more difficult to judge it on the thrown thread; however, as it is altogether

a matter of relative values, one can soon determine for himself when he is getting the best or worse organzine by following the method outlined.

The relative values I recommend, to range from one hundred per cent to seventy per cent, which are to be determined from organzine thrown from XX up to grade and No. 1 up to grade.

I am not giving any table for evenness and cleanness, as this would be only misleading should another method be used to determine the same, but I am showing how one may proceed to classify organzine and show that with the knowledge at hand this is possible and practical; also, to impress upon the buyer of thrown silk that since raw silk is not a perfect thread, one cannot expect a perfect thrown thread. There should, however, be a standard method by which organzine can be classified both for the benefit of throwster and buyer. If a throwster can take an extra grade of raw silk and produce by careful methods a XX grade of thrown, he should be able to sell it as such. If, on the other hand, another throwster takes the same grade of raw and produces by inferior methods only a Best No. 1 to extra, he cannot expect the buyer to pay the price of an Extra for it, and both should be able, by a standard method, to settle any dispute that may arise on the subject. Single threads are difficult to see in the undyed state, but are plainly seen after dyeing, as they become flossy and glossy. I find fifteen singles to one hundred pounds of organzine is a very bad condition, yet that would average only one-third of a single on 300,000 yards of two thread organzine. I consider one single to every one hundred pounds a good condition, yet if one saved all he found on a ten-bale lot he would have about thirteen, and if that fact was not considered and one was inclined to make claims, he might make a complaint against the throwster, which would not be justified. Of course, we say that he should not have any, but when we consider that in a ten-bale lot about 30,000 knots are tied in the doubling alone, you will readily appreciate that thirteen tied up on to a single end would not, in fact, represent a very bad condition nor represent any great loss to the manufacturer. This is not a plea for leniency for the throwster, but simply to show that he is at least entitled to a fair deal. For special purposes it may also be desirable to know the relative value of lustre. This can only be determined by making a boil-off test.

The grade of organzine is to be the average of the relative value of strength, evenness, and cleanness and throwing defects, adopting four grades, according to the following scale.

Classification	Per Cent
XX	100
	98
	96
	95
X	94
	92
	90
	89
Best 4 1 to Ex	88
	86
	84
	82
	80
	79
No. 1	78
	76
	74
	72
	70

Hard and slack twist are very hard to see in the undyed state, and if this proves excessive a claim for damage can be made, and therefore need not be considered in the quality.

Hairiness can be seen by looking across the face of the skeins, and if this is very marked the grade should be penalized one to five per cent.

PART III—CHAPTER VIII

THROWING

SOAKING

It is the general practice in America to soak silk before throwing, whereas in Europe the general rule has been to throw it bright or unsoaked; lately, however, especially in France, a considerable amount is sprayed with olive oil and allowed to stand over night. This raises a very interesting and important question—why this difference, and which is the proper method?

First: In the early days of the European silk industry throwing was done at very slow speed, and they are still operating slower than is the general practice in American mills.

The gums or reel markings of the skeins cause an excessive number of breaks when winding at high speed, even though the gums are rubbed and pulled apart dry. The high cost of labor in America makes it necessary for the American throwster to operate at the highest end or net efficiency; therefore, it becomes necessary to soften the gums before winding which is done by soaking.

Second: There are two general classes into which silk will be divided—that is, as far as it applies to friction, viz., rough and smooth silk. The hard nature silks like China and Kansai Japans are rough; frequently they contain grit, which causes the thread to cut the guide eyes, flyers, and other tensions in a much shorter time than the soft nature Shinshiu Japans and Italians. This makes a lubricant necessary, particularly at the higher thread speed.

Third: There are silks that are not only ductile, but also elastic. In mill parlance they are called springy. When these elastic threads are doubled and the thread catches on the pay-off bobbin at a slug, waste, bad knot or other defect, they cause the thread to stretch out and throw in a loop. This, however, does not happen when the thread is pliable, as the thread then stretches, relieves the tension and doubles up without any loop. When the silk is soaked properly that property is destroyed and leaves the thread more ductile and pliable.

Fourth: Unsoaked threads are also wiry and stiff. They swing off in a larger balloon, and where short first-time shafts are used, where spindles are close together, it is no uncommon occurrence to have the breaking thread swing over into the running thread, breaking it down, or run up double. This wiriness also causes uneven doubling.

Soaking always improves the silk thread for throwing into organzine, tram, crepe, etc.—that is, if properly done—but it does not always improve the thread for weaving in the gum; it is just possible that any kind of soaking, or even oil spraying, will injure its weaving qualities. In throwing, however, one has yet to find an instance where proper soaking does not always improve thread, except of course, Tussah. It is thus my purpose to make it perfectly clear that the following articles on soaking only apply to throwing of Japan, China, Italian and Canton silks.

Object of Soaking

The objects of soaking silk are: First, to soften and slacken the gums; second, to lubricate the thread and make it more pliable and ductile. The materials used are soap, oil, borax, salt and water. Soap is used to soften or slacken the gums in conjunction with the temperature of the bath.

Oil is to lubricate the thread and act as an emollient for the action of the soap and water on the silk. (The effect of warm water and soap on the sericin of silk is to soften it, but in the absence of oil it dries stiff, sticky, and hard, depending on the amount of soap used, the temperature of the bath, and the length of time the silk is treated. Oil coats the thread with a film of oil when properly emulsified and will prevent its drying to its original matted form and leaves the skein soft and fluffy.)

Water

The water should be soft and free from acid or alkali—in other words, neutral.

G. H. Hurst, F. C. S., in "Textile Soaps and Oils," says, "One pound of lime or Magnesium Compounds in a quantity of water will practically destroy five and one-half pounds of soap. Now many waters contain twenty-four grains per gallon of these objectionable matters, and if, say, 1,000 gallons of such water were used there would be present 24,000 grains, and these would consume or use up 134,400 grains, or nearly nineteen pounds of soap."

As waters are constantly changing, owing to rainy and dry spells, the hardness also changes and has varying effects on the soaking emulsion.

The lime or magnesia when present in large quantities unites with the soap and make a sticky and insoluble mass called lime or magnesia soaps. When present in less quantities it forms curds which attach themselves to the silk, give weight, but fail in both instances to give softening or lubricating qualities, and may interfere with dyeing and finishing.

It is therefore essential that the water be neutral, or, in other words, the lime, acids or alkali must be destroyed or its action overcome by another chemical, or some type of replacement softener.

Soda ash is the cheapest article that will do this, but it has been found by a series of tests run several months that it has a stiffening reaction on the silk when soaked in a light solution.

Softening Water

The method used for testing hard water, by the Standard Soap Solution. where the hardness is considered overcome when a permanent foam remains on

the water, has been found very satisfactory and has several advantages, which fully cover the cost of the soap used. It is worked as follows:

One hundred pounds of soap are boiled up in fifty gallons of water; when fully dissolved the water is increased to one hundred gallons, so that one gallon of soft soap represents one pound of soap. Then measure out the required amount of water needed for the silk to be soaked, pour in three pints of soft soap and stir. If a permanent foam remains for one minute on the water the lime present has been neutralized, and it is ready for use. (Two and one-half pints have been found necessary for condensed steam or one hundred gallons of water. This amount is required to saturate the water.)

If no foam forms continue to stir in pint after pint until you get a foam that lasts at least one-half minute. I have found waters taken from the same source of supply require but four pints in wet seasons and fourteen pints during dry seasons to neutralize or make inactive the lime salt. It will therefore be appreciated that as this hardness comes on stealthily it becomes necessary to be constantly on guard for it, and that whilst a water requiring four pints soft soap to one hundred gallons would never cause any trouble, nevertheless it becomes necessary to do it regularly to be sure of always having neutral water. Care must be taken to heat the water to within ten degrees F. of desired temperature, as when the water is treated when cold, and then heated up, an insoluble sticky soap rises to the top, which, if it gets on the silk, mats it together and makes it unwindable.

A number of reliable water softeners are now to be had at a reasonable cost, which require but little care and attention. Water softeners are recommended where the water is very hard.

Soap

Experience has shown that soap suitable for boiling-off is also the best to use in soaking.

"Soap (according to Geo. H. Hurst, F.C.S.) adapted for boiling off silk should be easily soluble in water, for fluidity means easy penetration into the substance of the silk fabric and also easier washing out of the silk afterwards.

"It is not necessary that the soap be quite neutral; a slight degree of alkalinity is rather of advantage, as silk gum is rather more soluble in alkaline solutions than in neutral soap, but it is better to buy a neutral soap and add the alkali yourself, as you will then know what you are working with.

"A good olive oil, palm oil, or an oleic acid soap may be used in dyeing. Tallow soaps are not suitable and should not be used."

The Quality of Soap.*

The quality of soap used for the stripping or boiling off is of some importance. There are so many qualities being offered to the silk dyers, made from all sorts of fatty matters, that care must be exercised in selecting the soap to be used. Much depends in this matter upon what is going to be done with the silk afterwards.

*Article on Boiling Off Silk. In Textile Mercury.

When the silk is to be white or dyed in pale colors the best oil soaps should be used white and free from unpleasant odors of any kind. Perfumed soaps should be avoided, as they are sometimes only perfumed to hide some unpleasant fatty odor. Olive oil and cocoanut oil soaps can be recommended; the latter can be used alone with very hard waters, as it is much more soluble in water than any other kind of soap. Cocoanut oil soaps must be bought with judgment, as they frequently contain much water, the existence of which cannot be judged by the outward appearance of the soap. For those colors (blacks, browns, etc.) where the silk passes through many baths the poorer quality of soap will do equally as well, as any odor they contain disappears during the process of dyeing. Soaps made from oleic acid, palm oil or tallow can be used for such purposes. The soap used should be neutral and free from any excess of alkali.

Silk Soaps

*For degumming silk nothing has been found better than a good olive oil soap. A silk soap should contain the following properties: It ought to be neutral, inasmuch as alkali tends to make the silk somewhat harsh and reduce its lustre, and it should be easily soluble. The soaps used in the boiling off of silk must be well made curd soaps, using as slight excess of alkali as possible and well salted out. The soap must also be capable of being readily washed out of the silk. A soap well made with potash and olive oil would be found to give excellent results in the boiling off of silk.

†Soap is employed in the treatment of silk in two ways, first for the purpose of boiling off the silk, that is, to separate the silk glue or sericin, with any dirt it may be contaminated with, from the true silk fibre or fibroin. To effect this without leading to any deterioration of the silk fibre as regards strength and lustre, it is necessary to employ a pure neutral soap and one which shall be freely soluble in water. On this account it is desirable to employ an oil soap, and the best oil to make it from is an olive oil, palm oil, cocoanut oil, or ground nut oil. Tallow soap is not soluble enough for this purpose and cotton seed oil is not satisfactory and can scarcely be made sufficiently neutral.

It appears, therefore, that in order that a throwster may be on the safe side it becomes necessary that he use a neutral olive oil soap, which always gives him a definite starting point and an article of known value which will always give good boiling out results on all dyes. Besides, as sericin is more soluble in alkaline solutions and as a throwster desires to preserve this part of the thread for good working results, a neutral soap only should be used.

Method of Putting Silk in Soaking Tub

The immersion plan of taking a bundle of silk and pushing it into the tub containing the soaking solution will, especially on an oil soaking, show a very uneven absorption for the reason that the emulsion is constantly breaking up, more or less. In other words, the oil is separating out of solution back to its original state, even though it stands but a minute. The top of the tub contains a greater per cent. of oil than the bottom, and in immersing the silk in it the first that goes in absorbs the extra oil, and consequently gets more than any other parts of the bale.

†American Soap Journal.
*Chemical Trade Journal.

The proper way is to prepare the solution in a separate tub, keeping same constantly agitated by hand or power. Pour, or, better, spray in one layer of solution and then lay in one layer of silk; follow with another layer of solution and then silk, laying the second layer across the first, and so on until the whole bale is soaked.

The spraying method consists of a boiling-up tank, mixing tank, soaking tub, and the necessary piping and spraying nozzle as illustrated by Fig. No. 32. The soap, oil and borax are boiled together in the boil-up tank, then run by gravity into the mixing tank. The purpose of the mixing tank is to soften the water and then mix with the emulsion run in from the boil-up tank. When the emulsion is ready for soaking, the valve is opened and about four inches of emulsion is sprayed into the soaking tub, then proceeding as already stated. If the elevation of the soaking room does not permit of a gravity system, then a centrifugal pump may be used, but care must be taken that the pressure does not exceed thirty gallons a minute, as a higher pressure mats the skeins and makes them unwindable; it also causes the emulsion to break down or separate out of solution and deposit the bulk of the oil and soap on the outside of the skeins, giving an uneven absorption. It is also necessary to keep the nozzle moving to prevent the matting of skeins. By this method the variation in the different parts of the tub is reduced to less than one per cent., whilst with the immersion plan they vary as much as six per cent.

The Amount of Water

You will readily understand that if no water were used and the soap and oil sprayed on the silk, we would get one hundred per cent. absorption, but there would be no softening effect, and all of the oil would be on the outside of the skeins. Eighty per cent. water, expressed in gallons, plus that obtained in bringing the soap and oil to a boil, has given the largest returns. Ninety gallons to the hundred pounds of silk shows a loss of about ten per cent. in absorption. It takes about eighty gallons to cover the average silk. Open diamond reels do not require as much and the amount absorbed is more uniform.

Tying Bundles

No more than six or eight skeins should be tied in one bundle, and these should be untwisted well so as to permit the emulsion to percolate through the skeins, and tied with strings on the full length of the skein, but not slapped out, as this causes a great number of loose ends which become tangled in soaking. Silk soaked with the skein unopened shows a very uneven absorption, the inside of the skeins showing sometimes no more than one per cent. absorption, the outside as high as four and five per cent. on light soaking, that should average about two and one-half per cent. The winding breaks are also increased because the soaking cannot reach the gum.

Effect of Atmosphere Conditions on Soaking Emulsions

Oil does not dry out even at 300° F. Therefore, no emulsion is lost in the mill room through evaporation. There is, however, a friction loss that is greater when the mill is dry than when humid, as the porcelain guides, plush cushions, drop fallers are so much more dry and will consequently rob the thread of a greater amount of oil.

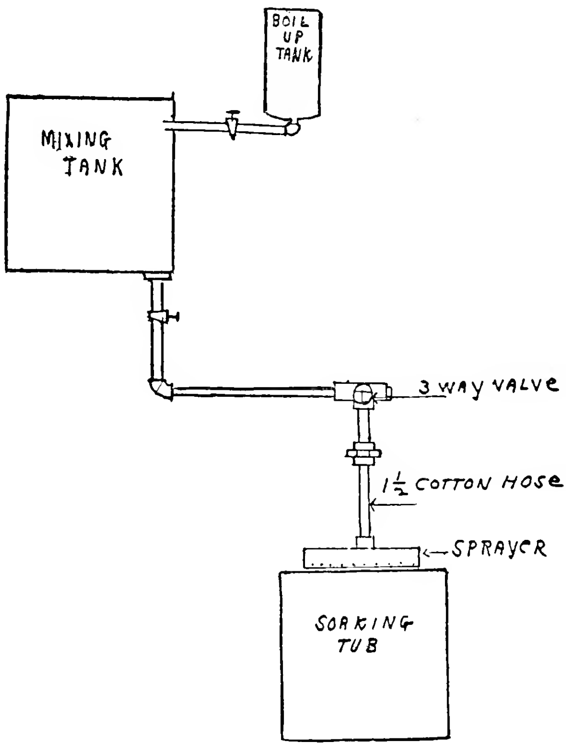

BOIL UP TANK
MIXING TANK
3 WAY VALVE
1½ COTTON HOSE
SPRAYER
SOAKING TUB

Fig. 32

It has also been found that a silk soaked with an oil formula shows a greater friction loss for the reason there is always a great amount of oil on the outside of the skeins, which attaches itself to the hands of operators, bobbins, guides, etc. Of course, the moisture in the thread will evaporate and appears to be greater on Japan than Italians, due to the greater amount of sericin in Italian silk binding the moisture in the thread.

A series of observations appear to show that the friction loss is from one-half to three per cent.

Absorption

The greater the amount of soaking solution taken up or absorbed by the silk, the less the amount of material needed, and consequently the cheaper the cost. The greater the softening properties of the solution the less, however, is its absorbing power, but the absorption is more uniform.

A permanent emulsion of soap, oil, and alkali is one in which the oil has been divided up into very minute globules of oil by the alkali, so that they unite with the water in such a manner that the emulsion remains in its original state, almost indefinitely. (See chapter on emulsion to follow.)

This kind of an emulsion has a good softening effect, but often has a stiffening reaction because of the lack of oil, to emulsify it—but very rarely more than thirty per cent. is absorbed by the silk. On a silk having no gum it is a great waste of material to use this form of an emulsion, besides the less the sericin of the thread is affected, the better will be the working results in the throwing. An emulsion then, consisting of the greater part of oil so made and applied that it will penetrate all parts of the skein uniformly, is the proper one to use.

After many tests it has been found that the minimum solution of one per cent. soap and four per cent. oil with proper amounts of borax and the right temperature, with the proper method of making and applying, gives results within the limits of allowance under practical working conditions.

An emulsion of this kind will absorb from sixty to eighty per cent. of the anhydrous material, depending on the chemical nature of the thread. N. Silberman, in 1895, found from 1.36 per cent. to 2.75 per cent. of wax and fat in raw silks; Gnehm, in 1903, found fatty matter to the extent of from two per cent. to 8.5 per cent. Japan silks. Thirty-two tests for acidity showed the soft natured Japans from 0.30 to 1.35 cc. N/10 KOH; hard natured Japans from 0.2383 to 0.275 cc. N/10 KOH; China filatures from 0.25 to 0.30 cc. N/10 KOH; Canton filatures from 0.515 to 0.575 cc. N/10 KOH.

Experiments show that the soft natured Japan silks, such as Shinshius, take up from ten per cent. to fifty per cent. more solution than the hard natured silks coming from the provinces of Okshui, Koshiu and Kansai, amongst which are those of Joshiu, Shinano, Seishui and Nisishiu cocoons.

It was observed on silks showing over 0.70 cc. acidity that they were of low grades and usually shaded, which appeared to show that a high acidity was probably due to dirty water in the reeling basins and also a lack of the necessary changes of water which became heavy with sericin, followed by a decomposition of same, causing the acidity named.

About one hundred soaking tests demonstrated that Japans showing under 0.30 cc. acidity do not take up more than fifty per cent. of the anhydrous emulsion, whilst those silks showing over 0.50 cc. acidity take up as much as eighty per cent. to ninety per cent. Since wax and fats shed water, or a soaking emulsion, similar to water on a duck's back, it would appear to indicate that there is some relation between the hard natured silks and those containing wax and fats, and the soft natured ones containing none. It was discovered by increasing the alkalinity in the emulsion that better and more uniform returns were obtained, which would appear to indicate further proof of the opinion. It was observed also that the higher the acidity the quicker the emulsion broke up, due to the action of the acid destroying part of the alkali, thus making a more temporary emulsion.

Tests were made with an oil formula of three-quarters per cent. soap, and eight per cent. oil, with which eighty per cent. and ninety per cent. returns were obtained. On hard natured Japan silks, with the immersion plan of putting in the silk, that in the middle contained but about two per cent. of oil, whilst that at the sides and top contained from eight per cent. to twenty per cent. It was also found that the inside of the skeins showed no trace of oil. With the spraying method the variation was reduced to four per cent. The skeins, however, dried stiff and hard and the winding results showed increased breaks.

Oils

An oil suitable for soaking silk must not become viscid or sticky, should boil out readily in the dyeing process so as to prevent flossiness or hairiness due to excessive boiling out, should not contain mineral oil, and it is desirable that it leave no odor.

Olive oil undoubtedly takes first rank as an oil suitable for silk throwing, as it answers every requirement, but on account of its price is rarely used. Neatsfoot, lard and red oil give good results, and in one respect are better than olive oil, in that they contain about fifteen per cent. more viscosity, hence form a better film of oil over silk; but they will always give the silk a strong odor, to which, however, there appears to be no objection.

Neatsfoot is generally used, and occurs in three grades, sold under many misleading names. The first grade, the Strictly Pure, contains the choice oil extracted strictly from the hoofs and refined, and shows less than one per cent. free acid; the second grade, called Extra (also called Prime), contains the second pressing, and usually contains about ten per cent. free acid; the third grade, generally called No. 1, is not a straight neatsfoot, but consists of the reboiling of the hoofs and other parts of the animal, including tallow, frequently cut with red oil (Oleic Acid), which is a product in the manufacture of glycerine, stearic acid and palm oil for candle making. It contains from eighteen to thirty per cent. free acid.

In order to establish its identity, its composition, its working qualities, and its money value, as it applies to silk throwing, it is necessary to conduct the following chemical test: First, free acid; second, Maumene's or temperature; third, mineral oil; fourth, iodine test. (Method of making these will be found in Textile Soap and Oils.)

Free Acid

Free acids are of two classes, viz., the fixed acids, such as Stearic, Oleic and Palmitic, and the volatile fatty acids, such as Butyric, Caproic, etc. The volatile class cause the bad odors.

Free fatty acids are very quickly changed to soap by the alkalies added to the soaking emulsion. Carbonate alkalies and oil, as will be further explained under "Emulsions," do not make soap except with that part of the oil being free acid.

The free acid largely governs the amount of borax required to make a standard emulsion, as the acidity destroys the alkalinity causing it to break down, or separate out of solution sometimes too quickly and causes an uneven absorption of emulsion by silk.

When oils with over ten per cent. of acidity are used they should be first neutralized, so as not to destroy the body of the emulsions, and also that the silk may absorb same uniformly. Besides if a high acidity in the raw oil is not neutralized it is liable to continue in the thrown silk, if same is stored in a moist warm place, and is liable to form maggots.

Maumene's or Temperature Test. Fatty oils are divided into three groups, first drying oils, like linseed or poppy-seed, which when exposed in thin layers become dry and hard. Second, non-drying oils, like olive, sperm, lard and neatsfoot, which always remain soft. Third, the semi-drying oils which become viscid and thick, such as cottonseed. While there is no absolutely fixed rule as to the increase in temperature that an oil treated with sulphuric acid may show, my experience has been to go slow with an oil showing a rise over thirty-two degrees C., as an oil containing half lard and half cottonseed showing a rise of thirty-eight degrees C., becomes so sticky on machinery that it costs fully one-third more to double and spin it.

The Iodine test is valuable to identify an unknown oil.

Mineral Oil

Pure mineral oil is very rarely used as a soaking oil and then only by the more ignorant or unscrupulous throwsters, but a great amount of mineral compounded with animal or vegetable oil with from thirty to sixty per cent. mineral is being used by throwsters today. As the consumption is on the increase, it appears timely to discuss this subject in connection with my article on soaking. The author has made extended investigations and finds that chemists do not agree as to the harm caused in dyeing, by the limited use of mineral. I can find no worthy authority on the subject. The dyers communicated with, say:

"The objection the dyer has to offer to the soaking of silk with mineral oils is that, as you know, mineral oil is insoluble and therefore does not saponify. When the mineral oil is all removed we use the soap for dyeing, and the mineral oil, being insoluble, is merely suspended in what the dyers call the gum soap solution, and as all silks for which the gum soap solution is used are dyed in an acidulated bath, the silk will take up the suspended mineral matter, causing dull places in the silk. In an acidulated solution silk has a great affinity for mineral, clay or any other matter of this nature.

"From the standpoint of the dyer, we are absolutely opposed to the use of any unsaponifiable or mineral oil in the operation of throwing. We know by experience that if the mineral oil used in throwing is not completely removed from the fibre, either in the boiling off process or in the soaping, in case of souples, we have considerable difficulties in obtaining level dyes, due to the fact that the silk has not taken the weighting evenly. On the other hand, you are well aware of the fact that all the gum soap obtained in the process of boiling off is used again for dyeing colors.

"Gum soap is of great value: it is our most important accessory and absolutely essential for obtaining level shades.

"Why then should we sanction the adulteration of this vital product? There are so many difficulties arising every day in our line of business that we are compelled to take a firm stand against the use of methods which we know will be abused sooner or later and cause untold troubles.

"The argument that neatsfoot oil and other vegetable oils are, on account of the high price, beyond the reach of the throwster, offers in my opinion, no excuse for replacing them with inferior products and preparations. We know of one concern which is doing its own throwing and which would never consent to use anything else but olive oil.

"Look at the prices we dyers have to pay today for chemicals and dyestuffs. Do you think for one moment we would dare to cut out the high priced products which we know by experience give the best results and substitute for them cheaper goods which somebody may think to be good enough? My answer in short is that 'The best is none too good for silk.'"

Unknowingly, I have used a soaking oil containing thirty per cent mineral and seventy per cent. neatsfoot for several years and never had a complaint as a commission throwster, even though throwing for twelve different customers during that period. When I made the discovery I purchased a specially prepared mineral oil, compounded it myself with quite a saving in cost, and used it for soaking. Special inquiry was made as to the boil-off and dyeing results, which were favorable in every instance, but on learning the dyers' objections and the possible injury that might be caused, I stopped its use and confined my soaking oils to straight neatsfoot and olive. From a throwster viewpoint, I find a thirty per cent. mineral with seventy per cent. neatsfoot gives a high absorption, excellent lubricating results, and altogether is a very desirable soaking oil as far as the throwster is concerned. There are, however, several precautions to be observed.

First. The mineral oil separates and rises to the top after standing awhile, particularly in a warm room. The oil should, therefore, be well stirred before using.

Second. It should never be used with hard water, as the lime and magnesia salts unite with the oil and make an insoluble sludge that attaches itself to the silk and resists boiling off. The water should be first softened.

Third. Temporary emulsion should be avoided (see emulsions) so as to prevent the oil separating out in blotches on the top of the tub, and giving the

silk an excessive amount of mineral oil. Since the mineral oil is unsaponifiable it separates out of solution much quicker than straight animal or vegetable oil.

Fourth. As the oil man may be tempted to increase gradually the per cent of mineral for greater profit it is necessary occasionally to test the oil for the per cent. of mineral contained in it, so as to keep it within a safe limit.

In conclusion I wish to state that I do not desire the trade to accept this as an endorsement of the use of a soaking oil compounded with mineral, as I have discontinued its use until such a time as dyers are willing to accept it, or raise their objections to the use of a soaking oil compounded with mineral; but as there are a great many throwsters now using it, and, I am told, without any complaints from dyers, I consider it timely to point out the precautions to exercise in its use, particularly the necessity to avoid an excessive amount of it.

Salt

The use of salt is to throw the emulsion out of solution, thus separating the oil and soap from the water. This property of salt, according to G. H. Hurst, F. C. S., "Depends upon the fact that while soap is soluble in water, yet it is insoluble in solution of alkaline salts, and when, therefore, such is added to the solution of soap the latter is separated out of solution." Salt has a weakening action on silk, therefore, in the opinion of the most reputable throwsters, it has no place in an honest emulsion.

The author has found that three and three-quarter ounces per one hundred pounds of silk yield from ten to twenty-five per cent. greater absorption and also assist in tinting crepes, etc. With this amount hardly any traces of the salt can be found in the silk, as the bulk of it goes out in the waste water.

I have heard of throwsters using as much as six pounds of salt to the hundred pounds of silk, which is of course only added to give weight and will seriously affect the strength of same, which practice should be severely condemned.

Carbonated Alkalies

Borax has the least solvent action on the sericin of the thread, and for this reason has been used for years for making soaking emulsions; it also belongs to that family that when boiled with oil will not make soap, but will saponify whatever free acid may be present and form a chemical change of it, called soap; this soft soap will unite with the body of the oil and form a physical change, dividing up the oil into small minute globules that will mix with water (called an emulsion), and afterward break up and attach itself to the silk.

Borax is a safe alkaline addition because it is only a "defensive" alkali against acids, and not an "aggressive" or offensive one like the carbonates and hydrates. Carbonated alkalies, such as soda ash, crystal sal soda (common washing soda), granulated sal soda, act the same as borax and are much cheaper.

Borax at its cheapest is worth \$.06½ per pound. Soda ash, fifty-eight per cent, equals ninety-eight per cent alkali, costs \$.01½ per pound. Crystal sal soda is made by letting a saturated solution of soda ash crystallize, contains twenty-one per cent alkali and seventy-nine per cent water, and costs \$.85 per

cwt. Granulated sal soda contains fifty per cent alkali and fifty per cent water, and costs $1.75 per cwt. (Normal prices before the war.)

Soda ash is approximately three and one-third times stronger than borax, and when used in the proper amount gives the same results as borax. An excess, however, will exert an aggressive alkaline action and tender the silk fibres.

Cocoanut Oil and Glycerine

I can find no good reason for using cocoanut oil or glycerine in soaking excepting to weight the silk, and even this is a wasteful procedure, as almost any desired weighting can be obtained by olive or neatsfoot oil if the emulsion is made temporary enough.

I can find no harmful effect on the silk, nor can I find any lubricating results from glycerine. Cocoanut oil is a good lubricant, but is always higher in price than a neatsfoot. The greater absorption received in using part cocoanut oil is obtained from the fact that cocoanut oil requires a great amount of alkali to saponify; and emulsions made from it break down quicker and separate out more fully. This is not intended to justify weighting in throwing, but simply to explain how greater absorption is obtained in using glycerine and cocoanut oil.

Temperature and Time

For throwing it is my practice to leave the silk in soaking tubs over night, which gives from twelve to fourteen hours soaking.

My experiments show that on the emulsions given the maximum absorption is obtained in nine hours, and after that a softening action takes place which is very desirable for efficient winding results, as well as uniform doubling. I have thoroughly investigated the effect on strength, cohesion and working qualities, and have yet to find that over-night soaking has any harmful effect on raw silk for throwing, but on the other hand has given more efficient results.

I have heard a great many discussions as to the proper temperature to use for silk and its action on silk. I have found that Japan silk soaked at eighty-five degrees F. gives the maximum absorption. At seventy-five degrees about seven per cent less, ninety-five degrees ten per cent less, very hard nature Japans and Chinas excepted.

On Chinas I vary the temperature according to the hardness of the gum, frequently going as high as one hundred degrees F. I am fully aware that this practice is condemned by a number of silk men who use only from seventy degrees to eighty degrees F. on Chinas, but they are mostly men who have formed their opinions from results in single weaving, for which these formulae are not intended, as has been explained in the opening chapter on soaking.

Emulsion

Soaking emulsions are a physical mixture of soap, oil, water and carbonate alkalies; the alkalies generally used are borax and sal soda. By physical mixture I mean one in which the material has changed in form, yet not changed in its character, and under favorable conditions will separate out into its original state. This same material can be taken, and with caustic alkalies a chem-

ical change be brought about in which a new substance has been created, called soap.

Emulsions can be made temporary or permanent; they may be made of soap and oil only, but where the soap is much greater than the oil any excess caustic alkali in the soap unites with the oil and brings about a chemical change of a part or whole of the oil called saponification, which is hastened or progressed by boiling. In this instance it is a diluted soft soap rather than an emulsion, and its action on silk is to soften and strip the sericin, depending upon its strength, the temperature and time the silk is left in the bath; on drying it becomes hard and stiff, instead of soft and fluffy, for want of the oil to emollify it.

A temporary emulsion is one in which the globules of oil are so large that they break up, or separate out of solution inside of one minute's time. These are made by using only one-half per cent soap to seven per cent oil. They, however, are so temporary and the oil globules so large, that they do not enter the skeins and take up very unevenly.

A permanent emulsion is made by increasing the soap and alkali in such proportions that the oil globules are made so small that they enter in between the water molecules and become fixed and remain in suspension almost indefinitely. Where the soap is strictly neutral and the per cent of carbonate is of the proper amount no chemical change is effected, excepting with the free acid that the oil may contain, which is dwelt upon more fully under oils.

A proper emulsion then, is one in which the material is of such proportions that a physical change only is brought about, that has a slacking or softening action on the gums or sericin of the thread; the oil globules must be of such a size that they will penetrate the skeins, surround the thread with a film of oil, and prevent the skeins from matting together again in the act of drying.

The following are good formulae for regular organzine and trams:

For Japan silks without gums per one hundred pounds silk:

Formula No. 1

Soap	1¼ pounds
Oil	5 pints
Borax	6 ounces
Temperature	85° F.
Water	80 gallons

Silk absorbs 3.40 to 4.30%.

For Japan silks with gums:

Formula No. 2

Soap	3 pounds
Oil	4 pounds
Borax	1½ ounces
Temperature	85° F.
Water	80 gallons

Silk absorbs 3 to 4.30%.

For China filatures, medium and hard gums:

Formula No. 3

Soap	3 pounds
Oil	4 pints
Borax	1½ ounces
Temperature	85° F. to 100° F.
Water	80 gallons

Silk absorbs 3.25 to 4.50%.

For Italian with or without gums:

Same as Japans except temperature, which keep down to 80° whenever the water supply permits.

For Cantons:

Formula No. 4

Soap	6 pounds
Oil	8 pounds
Borax	3 ounces
Temperature	85° F. to 90° F.
Water	80 gallons

Silk absorbs 6 to 8.50%.

These formulae are made up to go with a humid mill room; where means for humidifying are lacking, the proportion of soap and oil must be increased evenly on Japans with no gums to one and three-quarters soap and seven oil, and in like manner with other silks excepting where heavy formulae are already used. The reasons for this will be explained under effects of atmosphere on soaking emulsions.

Special Soaking

Hosiery Tram.—Silk knitters need a soft uniform thread that rapidly absorbs water or an emulsion. The knots also must be as small as possible and it is customary to tie a flat, or weaver's, knot so that it will pass through the knitting needles. A knot tied on a hard and wiry thread is much larger than one tied on a soft thread. Winwick says: "It is necessary to condition the thread, which is done by drawing the thread over a slowly revolving roll which runs through an emulsion in a trough. The emulsion should be of medium density and there is no oil equal to olive oil for this purpose. This process deserves more attention than it sometimes receives. Right here in the conditioning the manufacturer may make or lose his reputation or his money. It is all important that the thread be just moist enough and not too moist. An uneven dampening or undue adhesion, caused by the silk being too wet, would cause the silk to knit unevenly. Considerable difficulty was formerly experienced through settling of the slack silk about the base of the cone at the end of the course, but this has been overcome by the use of a large felt washer at the base of each cone. If the machine is in good working order and the silk thread in perfect condition, we should not be able to find any trace of cockling or what is sometimes called pin hole knitting. Cockling at the knitting machine cannot be remedied by any subsequent process of finishing and this is the reason why so

much attention must be given to the conditioning of the silk thread. A temperature of seventy degrees Fahrenheit has been found to be the best adapted to silk knitting."

Japan Shinshius are generally used for hosiery tram because of their soft nature, but unfortunately what is sold for a Shinshiu is anything from a hard nature to a soft nature silk. The hard nature sheds water like a duck's back and when this is not corrected in soaking it makes a very changeable thread that causes the cockling mentioned by Winwick. This may be largely overcome by using borax in the conditioning trough, but as the hard nature also is the cause of larger knots a perfect hosiery tram can only be made by a proper soaking formula.

Under the present methods employed in Japan it is impossible to get a sufficient amount of silk that is strictly uniform in its nature and it therefore becomes necessary to determine the hardest nature that is received and treat it in a way that will not affect the soft natured silk contained in the same lot.

A formula that will do this generally yields heavy returns and therefore justifies the twenty-five per cent boil-offs. Quite frequently the boil-off with the same formula will yield as high as twenty-seven or even twenty-eight per cent boil-offs and must not be taken as an attempt to weight the thread for greater profit.

Crepe and Other Hard Twists

Borrowing an incident from Southern life, where the colored race are offered antikinkites for which is claimed that they will straighten kinky, knotty, and curly hair, we have hinted at what is needed in setting the crepe and other hard twists so that they become workable. The greater part of all of the remedies offered is petrolatum, known in commercial life as vaseline. This would be an excellent treatment for crepes were it not a product of petroleum, causing trouble in dyeing as has already been explained under oils.

The best we can do is to soak the silk heavily and increase on the three soap and four oil formula until the desired results are obtained. A temperature of ninety degrees F. has been found to give the most uniform tinting and make the thread mellow.

The actual needs of this thread are a heavy soaking and therefore justify heavy clearances. The setting of the thread will be treated more fully in chapter on crepe twisting.

Methods of Preparing Emulsions

Soaking generally must be done within a limited time, therefore, the material should be so prepared that it will be in the readiest form.

First. Prepare the soap by boiling up with water so that when complete it will give one pound soap to one gallon liquor.

Second. The oil to be kept in its raw state.

Third. Measure out the required water in tub. Heat up to within ten degrees of temperature called for and then soften (see chapter on water).

Fourth. Measure out the soap, oil and borax called for in boiling up tank and bring to a quick boil. Run into tub containing the softened water and paddle well.

Fifth. Paddle well, get proper temperature and then spray on silk.

PART III—CHAPTER IX

WINDING

Type of Machinery

The two principal types of hard silk winding frames are what is commonly known as the spindle winder, with single or double head spindles, and the drum takeup as shown by Fig. 33. The most modern is the drum winder where the bobbin rests on the friction roll or drum, which is nearly the width of the winder bobbin. The thread speed, or the number of yards wound up per minute, is constant throughout, as the revolution of the winder bobbins decreases in the same proportion as the bobbins fill up, the same as the takeup shaft on spinning with friction rolls. This is the most important feature of this method.

The second feature is that there are no spindles to take off or put on. It takes thirty-five minutes a day with spring spindles to doff one hundred bobbins; with screw nut spindles it takes 105 minutes; on drum winder doffing takes only fifteen minutes a day on one hundred spindles.

Third, there are no spindles to chalk, replace and turn down heads to even them up, therefore showing a saving in spindle cost.

Fourth, a higher thread speed can be maintained. On the spindle winder at an average of 210 thread speed, that is when the bobbin is half full (size of bobbin barrel one and three-eighths inches, head two and one-eighth inches) the empty bobbin starts to wind up at the rate of 180 yards per minute and takes up at the rate of 237 yards when full.

The breaks increase about twenty per cent on 13/15 denier silk after 225 thread speed, with six-arm, pin hub swift, unweighted. It will therefore be observed that to gain the highest efficiency of winding cost it will be necessary to wind under 225 thread speed or an average of about 200 thread speed. On the drum winder a constant thread speed can be maintained of 200 to 215 yards on 13/15 denier silk, showing a gain of seven and a half to ten per cent in production per spindle.

The faults of the drum winder are that when the bobbin runs idle on the drum the silk thread opens up or splits, causing bad spinning.

Second, the winder bobbins must be exactly uniform.

Third, a positive tension is a hindrance to efficient winding; when there is no release to the tension, if the thread gets tangled in the skein it snaps off; but when there is a release, it often pulls through without a break.

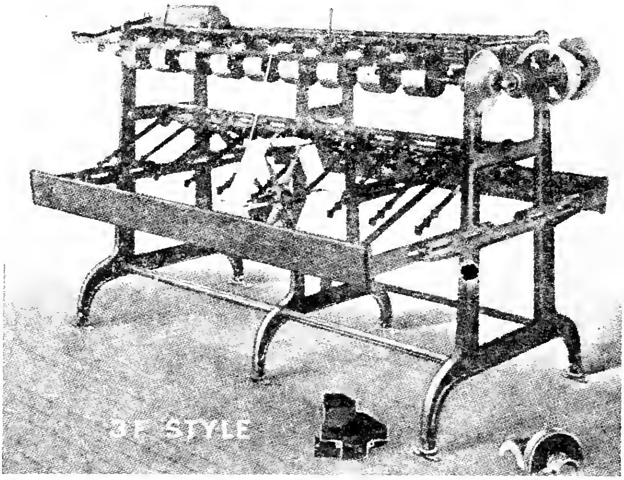


Fig. 33

(Dimensions of 60 Spindle Frame· Length, 18 feet 4 inches; width, 4 feet 2 inches; driving cone, 3, 4, 5, and 6-inch diameter for 1¼-inch belt. The frame is steel, strong and rigid, with deep shelf on top. New patented traverse motion with adjustable cam. Can be furnished with automatic screw traverse motion if desired, giving a perfectly smooth wound spool. Either the regular spindle take-up with single or double head drive is furnished, or the drum take-up with open fingers or swinging bobbin-hangers, as desired. The drum take-up gives uniform speed of wind, greatly increasing the product over the spindle take-up. The Swift hangers are adjus table for height and have triple bearings for various size Swifts. The knee-rails are adjustable. Drive is by cone pulley and cross-head, either geared or variable speed cones. Provision is made for attaching electric drive. All gears fully protected by shields. Built any desired length. Can be fitted with redrawing description.—Catalogue description.)

The maximum speed at which silk can be wound most economically on the drum winder will be governed largely by the weight of the winder bobbin or the release given by same, and must be found by a test to determine at what speed the breaks increase per yard.

The single head winder spindle, one and one-quarter inch head, gives a good release, and my experience is that the highest net winding efficiency can be attained with a single head winder spring spindle at 200 average thread speed on size 12/14 denier and over, swifts six arm pin hub unweighted.

Swifts. The Screw Hub Balanced swifts, or adjustable swifts, see fig. 34, show ten per cent increased breaks per yard over 185 thread speed on 13/15 denier silk; they are also more difficult and expensive to keep in repair.

The manufacturer claims, however, great economy in their use and that very few repairs are necessary as they are now constructed. They say that

they are being used extensively and those who have adopted them claim much greater economy in winding with less waste.

This new type of swift is adapted for skeins having a difference of eighteen inches in circumference.

Each tip or support is moved outward or inward simultaneously by turning any of the gears, and requires no fastening.

The use of this swift gives a perfectly balanced load, effectually preventing racing, allowing the skein to be run at a higher rate of speed and resulting in smooth, hard filled bobbins.

It is made in three sizes, the smaller is fifteen inches to twenty-two inches; the medium eighteen inches to twenty-five, and the larger twenty inches to twenty-seven diameter; the hub is usually made with gudgeon or pin bearings, but can be fitted to run on a stud or positive bearing, if desired.

It is made from thoroughly kiln-dried stock and fitted so as to allow for the usual changes in mill temperature, but should not be allowed to become wet or exposed to unusually damp atmosphere.

In my experience the six arm, pin hub swift, gives the most efficient winding results in point of production, winding cost and swift repair.

Winding Speeds

The following table gives the various speeds on four step cone winder:

Main line shaft, 266 R. P. M.

Cones on shaft, 7"-6"-5".

Cones on machine, 6"-5"-4"-3".

Diameter of friction roll, 4½"; Spindle Head, 1¼".

Diameter of Bobbin Head, 2⅛"; circumference, 6.67".

Diameter of Bobbin Half full bobbin, or average, 5.50".

Cones.	Speed of Friction wheel shaft.	Spindle Speed.	Thread Speed		
			Max.	Min.	Average
5 to 6"	221 R.P.M.	795 R.P.M.	147	95	121
6 to 6"	266	957	177	115	146
6 to 5"	319	1148	212	138	175
7 to 5"	372	1330	248	160	204
7 to 4"	465	1673	310	200	255
7 to 3"	620	2232	413	267	340

The winding speed is rarely changed on sizes over 12/14 denier. No efficiency is found by winding weak silk at a slower speed than 220 maximum thread when using six arm swifts unweighted with a single head spindle. The breaks per hour per spindle are less of course on slow speed, but not per yard, or at least there is not enough difference to make it worth the change.

On the double head winder spindles or drum winder a change in speed becomes necessary to give the thread time to draw out or disentangle and prevent breaks, as there is not enough release on the takeup.

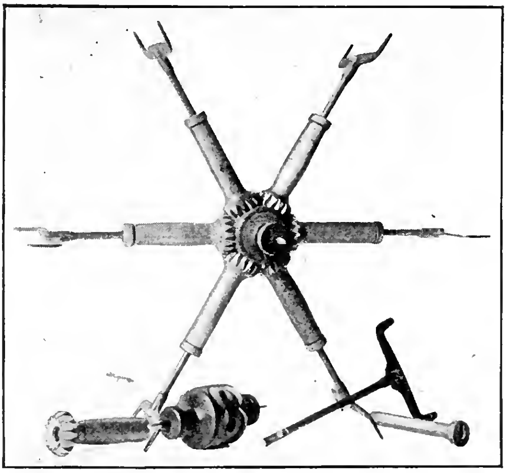


Fig. 34

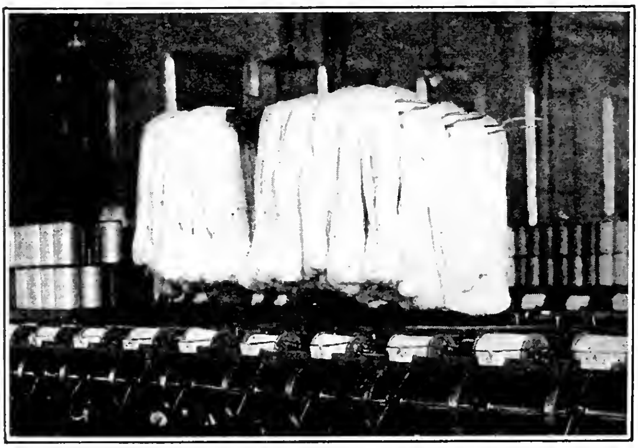


Fig. 35

Thread Speed

To determine the thread speed from the swift speed use the following rule: Fold the skein double and measure its length on inside, multiply by two and reduce to yards; this times revolution of swift per minute equals thread speed.

e. g. Swift speed, 120 R. P. M. Skein, 29″ long double = 161 yards cir. We have $120 \times 1.61 = 193.20$ thread speed.

For method of making winding count see Chapter IV on Classification of Raw Silk.

Production per Spindle

The production for spindle at say 200 average thread speed in a 14/16 denier silk=

$$\frac{200 \text{ yards} \times 60 \text{ minutes}}{300{,}000 \text{ yds. per pound}} =$$

.04 pounds per spindle hour, eighty-five per cent efficiency can be maintained, which gives the production $.85 \times .04 = .34$ pounds per spindle hour. Sixty spindles ten hours $= 60 \times 10 \times .034 = 20.40$ pounds.

Waste

The necessary waste depends on the number of breaks per yard and the condition of the skeins. A reliable table will be found in Chapter VI.

Dandering or Skeining

Experienced winders should do their own skeining as they use greater care in putting on their own skeins. However, where there are many learners it is better to have danders until the winders can do the skeining properly themselves.

Condition of Silk

The silk should be opened and hung up for natural air drying, winding the silk with from fifteen to eighteen per cent of moisture in the skein. The ends can be found ten per cent quicker when skeins are dry than when wet as it is taken from the whiz. Silk kept wet, or as it is received from whiz, and wound in that condition, causes the thread from the top of the skein to become over-stretched and permanently elongated; the under part of the skein, which usually becomes dry in the time it takes to wind down to it, does not contract the same as the silk wound from top of skein; the result is a more or less cockled thread of organzine.

Drying Trucks and Rack

The drying trucks and racks should be constructed so as to reduce the handling of silk to the minimum.

By making the racks transferable the work can be reduced to two handlings, first from the soaked silk to drying racks; second, from the racks, which have been transferred to top of winding frame, to the swifts.

Twenty-four hours are required to dry silk in the mill room by natural air drying to a proper moisture content for efficient winding.

See Figs. 35 and 36 for an ideal Drying Rack and Truck.

Air Condition

The humidity should be maintained at about seventy-five per cent at a temperature of seventy to seventy-five degrees Fahrenheit. It is well during dry weather to start up the system an hour or two earlier in the morning.

Bobbin Boards

Bobbins should all be handled on boards. These boards should not be too heavy so they can be readily moved on top of spinning frame to position where hand is working. Bobbins handled in this way prevent the heads from becoming rough and affect spinning results, also save waste.

Rubbing Gums

In rubbing out gums the best results are obtained on fine sizes by hand rubbing or combing with a hand comb having a round music wire tooth as shown by Fig. 37. A rubbing machine is also manufactured by Harry C. Smith

Fig. 36

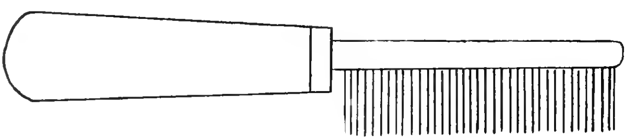


Fig. 37

& Co., as shown by Fig. 38, which gives good results on 16/18 denier or coarser size. Whatever method is used care must be taken not to rub the gums too hard and split the thread which affects winding results.

Defects in Winding Room

The defective work that may be made in winding is:

Hard bobbins.

Soft and crimpled bobbins.

Long knots.

Looped ends.

Waste and cord in bobbin.

Concave, convex and ridgy bobbins.

Bobbins run up on end.

Hard bobbins are the result of improper soaking, winding silk too wet or of its being wound in too humid an atmosphere. The real cause is that the silk is kept wet and warm too long and the sericin starts to decompose, which makes

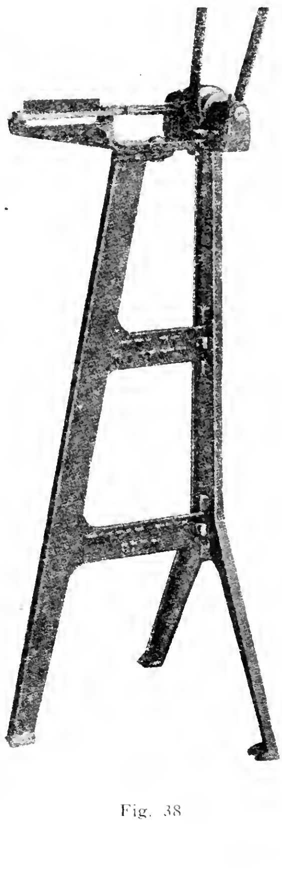


Fig. 38

the threads sticky and mats them together in drying on the bobbin. The only remedy is to open up and dry the skeins before winding.

These hard bobbins cause corkscrews in organs on the combination spinner and loopy trams in doubling. They also affect first time spinning.

Long knots, waste, and cords in bobbins affect spinning, and tram doubling as the loose ends catch and break down the thread.

Soft and crimpled bobbins cause uneven doubling on tram.

Concave bobbins, low in center, do not affect spinning, but convex bobbins, high in center, do affect spinning, the same as those having ridges. Bobbins run up on end pay off faster and throw in a loop on doubling.

Looped threads are caused in finding the end on the bobbin and are solely the fault of the winder. Sometimes when the thread breaks, the end wraps loosely on the bobbin; in stroking the bobbin to find the end it somehow gets crossed under the thread and this should be broken out. This trouble appears mostly on wiry silk.

These looped threads cause an increased tension and uneven doubling.

PART III—CHAPTER X

FIRST AND SECOND TIME SPINNING

Type of Machines

There are two types of spinning machines, the single and double deck.

On first time spinning the standard friction rolls are two and a quarter inches wide; the second time rolls are three and one-sixteenth inches wide. The latest model spinners are shown by Figs. 39 and 40 with manufacturers' claims.

Size of Friction Rolls

A number of advanced throwsters use the standard second time friction rolls for both first and second time spinning because of greater efficiency and the convenience of making hard twists and other special threads. Owing to the closeness of the spindle on the narrow roll machines, the breaking end frequently swings over into the running thread, thereby causing twenty-five per cent. of the breaks, and unnecessary labor cost and waste. On the wide rolls this loss is reduced about twenty per cent. Because of the closeness of the spindles, flyers are difficult to use, and when used, the small size bobbins make the cost of operation excessive. On the narrow rolls, with loose pin fibre shafts, they have a tendency, when the rolls become worn on edges, to fill up unevenly and shift the top layer of thread over each other; this causes unnecessary breaks, excessive waste and uneven doubling. The wide rolls overcome this defect to a large extent, and the losses are reduced to the minimum. They also permit the use of a larger shaft and spinner bobbin. The difference in cost per pound between narrow and wide roll, calculating twelve per cent. for interest and depreciation on the increased cost of machinery and floor space, is about one-quarter cent per pound greater on the wide rolls.

Power Consumed

A great proportion of power consumed for spinners is taken by the belt transmission; tests taken with a first time double deck spinner of 244 spindles, with one inch diameter whorls, at 12,000 revolutions per minute, with all spindles removed from the belt, showed 1.75 H. P. used by the belt transmission alone. The belt speed reduced, to give 12,000 R. P. M. with a 13/16" whorl, shows 1.50 H. P. with spindles removed from the belt. This shows the advantage of using

the smaller and lighter whorl. In both tests the ball bearings were used on the belt drive and take-up. The one inch diameter whorl spindles were replaced without bobbins and the power then used was three H. P. or seventy per cent. increase.

Perfectly balanced and true running bobbins were then added; the power then required was 3.9 H. P.

The run of the mill bobbins, some of which were badly out of true, were then tested in place of the selected ones and the power required was 5.75 H. P., an increase of forty-eight per cent.; this shows the great importance of using only perfect bobbins. In these tests, ball bearing spindles were tested under same conditions, giving results of 2.05, 2.45 and 4 H. P. respectively.

POWER CONSUMED ON SPINNERS.

Tests conducted by The General Electric Company.

Spindle Speed	No Bobbins	True Running Selected Bobbins	Run of Mill Bobbins Not true	No Bobbins	True Running Selected Bobbins	Run of Mill Bobbins Not true
		Horse Power used.				
8000	1.	1.15	1.7	1.5	1.8	2.4
9000	1.15	1.35	2.1	1.85	2.3	2.9
10000	1.4	1.65	2.6	2.2	2.75	3.55
11000	1.7	2.	3.15	2.5	3.3	4.4
12000	2.05	2.45	4.	3.	3.9	5.75
14000	3.	3.05	7.	4.1	6.	No test.
15000	3.6	4.2	10.			
	Ball Bearing Spindles 1" Whirl			Regular Spindles 1" Whirl		

The above test made on Atwood Machine Co.'s double deck 8B style spinner first time of 244 spindles with ball bearings on the belt drive and take-up.

Tests made with the 8B single deck 114 spindles, 13/16 whorls. Ball bearings on belt drive and take-up—11.060 rev. .85 H. P.

Regular bearings on belt drive and take-up—10.750 rev. 1.25 H. P.

Roll Covers

With loose pin fibre take-up shafts, narrow or wide rolls, it is necessary to cover them with cork so as to get enough tension to break the thread when it catches on drag wires and holds back the shaft, so as to prevent rubbing on the rolls or chafing the silk. This also is necessary on hard twist so as to avoid slipping and give a uniform twist.

Herrs Treated Leathers are now being used as a substitute for cork and while the first cost is greater, their life is almost indefinite, as cork wears off on the edges in about four years' time and causes a ridge on both sides of shaft, which on a first time shaft pays off faster in doubling, overruns and throws in a loop.

Single Deck Spinners

The advantages of single deck spinners are better light, cleaner silk, less spindles stopped when changing lots or repairing drive and spindle belts, less heat in the aisles, and suitability for female help; as the female help remain about two years longer in the mill than males, this is a decided advantage. They can also be operated about five per cent more efficiently.

The disadvantages as compared with double decks are double the floor space, and power transmission.

Double Deck Spinners

The advantage of double decks are one half the floor space and power transmission.

The disadvantages are less efficiency in piecing up and doffing lower deck, dirty silk on lower take-up shaft; unsuitability for female help, excessive heat in aisle during hot weather, and help hidden from view of forepeople.

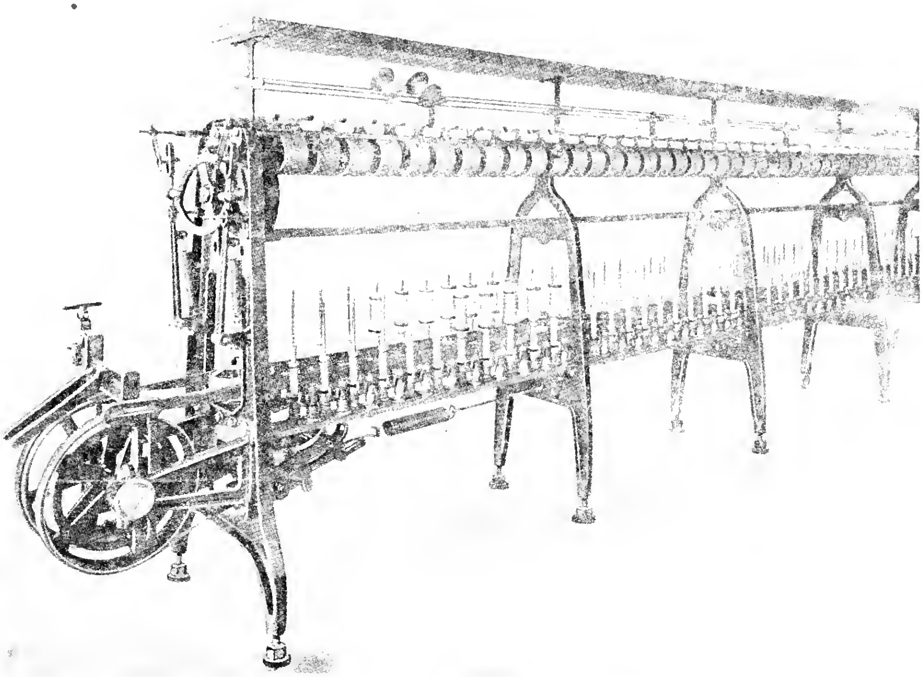


Fig. 39

The difference in cost of machinery, floor space, power transmission and bobbins between an organ equipment of single deck wide rolls, both first and second time as compared with a double deck narrow rolls for first time and wide rolls for second time, is about $400.00 to produce one hundred pounds of organ. Counting twelve per cent interest and depreciation on the $400.00, the increased cost is $0.0075 per pound on organzine, but when deducting the greater efficiency of operatives, or the saving in labor cost, the difference is only about $0.0025 per pound in favor of the double decks. These calculations have been based on good labor conditions and nothing has been allowed for less turnover in help on the single deck. If this is counted then the single deck equipment will show a good return for the increased cost of investment.

Spindle Speeds

The spindle speed of a spinning machine may be determined by several methods:

First, it may be taken by a speed indicator or speedometer placed on the tip of spindle; care must be taken that speed is not retarded, and that a taper contact tip is used that fits tightly on top of spindle. It is necessary on the swinging spindle to hold the spindle against the belt and avoid a wobbling spindle. The average should be taken from at least five spindles from different parts of machine.

Second, it may be obtained from the revolutions of the head end shaft.

Rule—Multiply the R. P. M. of the head end shaft by the diameter of the spindle driving pulley and divide this result by the diameter of the spindle whorl.

e. g.—Speed Head End Shaft 800 R. P. M.
Diameter of Spindle Driving Pulley 15″.
Diameter of Spindle Whorl 1″.

$$\text{We have } \frac{800 \text{ R. P. M.} \times 15 \text{ inches}}{1''} = 12{,}000 \text{ R. P. M.}$$

as a constant we have $\frac{12{,}000}{800}$ or 15, therefore when the spindle driving pulley and whorls are alike fifteen times the speed of head end shaft equals the spindle speed.

Third, it may be secured from speed of take-up cork rolls.

Rule—Multiply the R. P. M. of the take-up rolls by the circumference of the roll in inches and this result multiply by the number of turns per inch for which the machine is geared.

e. g.—Diameter of Take-Up Roll 3¾″, Circumference 11.81″. Speed of Roll 70 R. P. M.
Turns per inch 16.

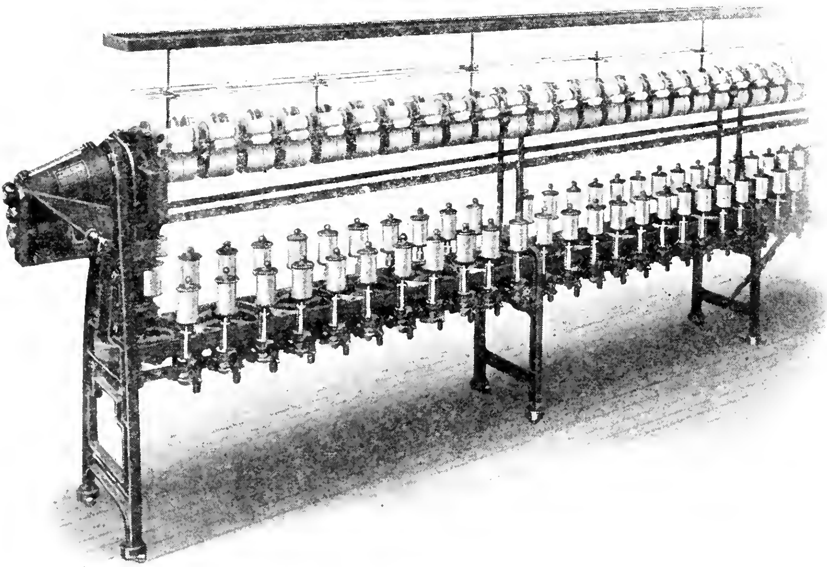


Fig. 40

[On our spinning frames we offer the following advantages:

Economy in floor space, maximum width fifteen inches.

Take-up rolls driven by spindle belt, when spindle belt breaks, frame stops instantly, which obviates any danger of slack twist.

Replacing broken spindle belts, without removing any parts, allowing you to keep one belt always spliced ready for use.

Changing of twist without the removal of a gear or pulley, from one to twenty changes furnished with frame time for making change thirty seconds, will furnish set of gears for special work without cost. One set changing whole range to twenty other than standard twists.

Change from tram to organ, by sliding gear on cone shaft, time about one minute, no new gears or parts to buy.

Change to opposite twist, by unfastening front pulleys and reversing same; this is accomplished without throwing any part of machine out of alignment.

Spindles, stationary with adjustable idlers, can be adjusted without use of wrenches, this arrangement permits of high speeds, as the idlers and not the spindles are affected by any inequality occurring in spindle belt.

All take-up rolls covered with cork.

New patent spindle lock, nut lock and compression spring combined, which avoids any accidental displacement of spindle from bolster and which locks nut securely avoiding nut coming loose from spindle step.—Scranton Silk Machine Co.]

We have,

Spindle Speed = 70 R. P. M. × 11.81″ × 16 turns = 13,227 R. P. M. When the circumference of roll and twist is uniform then the constant is 189, or 189 times speed of take-up roll equals spindle speed.

Fourth. Indicate feet per minute with cut meter, see Fig. 41.

Rules—Reduce the number of feet indicated by cut meter to inches by multiplying by 12 and this result multiply by turns per inch.

We have,

Spindle Speed = 68 feet per minute × 12″ per ft. × 16 turns = 13,056 R. P. M.

When the twist is the same then the constant is 192 which times feet per minute indicated equals spindle speed.

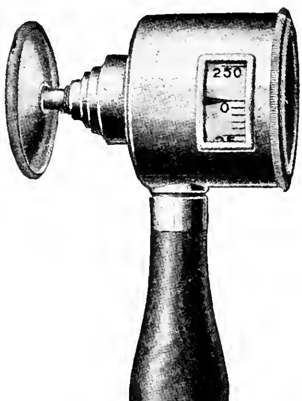


Fig. 41

The Warren Cut-Meter is used to denote the number of feet of paper passing over the rolls in feet per minute. For instance, if the circumference of the wheel is exactly one foot, it requires only one revolution of the Cut-Meter shaft to register one foot. If the wheel is six inches in circumference, it can readily be seen that it will rquire two revolutions of the Cut-Meter shaft to indicate one foot on the dial, so that it remains to properly calibrate a Cut-Meter in order to get the direct reading in feet per minute. The Warren Cut-Meter gives readings that are extremely accurate, and the length of the scale, which is six inches, enables the operator to read the very slightest variations in speed.

Speed First Time Spinners

With the Atwood Standard Spindles 12,000 to 12,500 R. P. M. is the most efficient speed in point of repairs, power, operating cost and even twist. When increasing speed the power required does not increase in proportion to the pro-

duction but in proportion to the square of the speeds; thus, a spindle speed of 15,000 would require, if 12,000 takes 1.75 H. P. $\frac{15{,}000^2}{12{,}000}$ $\times$ 1.75 H. P. = 2.75 H. P. or an increase of fifty-five per cent. The increase in production = $\frac{15{,}000}{12{,}000}$ = 25%, therefore to produce the twenty-five per cent. additional production would take fifty-five per cent. more power.

In addition to the extra power cost is a very low spindle life, only about one-quarter that of 12,000 R. P. M. double the cost of spindle belting and machinery repairs; against the high spindle speed we must charge:

First, extra power equipment thirty per cent.

Second, increased power cost thirty per cent.

Third, spindle repairs about four times greater.

Fourth, extra spindle belting fifty per cent.

Fifth, machine repairs fifty per cent extra.

Sixth, labor cost twenty per cent extra.

Seventh, extra breaks and waste.

These items add to the spinning cost at 15,000 R. P. M. as compared with 12,000 R. P. M. about $0.04 per pound. The cost of producing the twenty-five per cent increased production is about $0.15 per pound.

In favor of the higher speeds are:

Twenty-five per cent less machinery.

Twenty-five per cent less floor space.

Twenty-five per cent less power transmission.

Calculating fifteen per cent. wear and tear on machinery and five per cent. on building, shafting, etc., we realize a saving of about $0.15 per pound for the above three items. The net result is to raise the total cost $0.024 per pound or produce the twenty-five per cent. additional pounds at $0.11 per pound over and above the cost at a 12,000 spindle speed.

Ball Bearing Spindles

No personal tests have been conducted on these spindles but I have learned from reliable sources that so far the spindles give but a short life and that when the speed is run over 14,000, then the belt idlers and head end drives must also be ball bearing and the machine built extra strong to stand the higher speed. The power is claimed to be thirty per cent. less than the regular spindles. Occasionally one hears of machines being run at 18,000 spindle speed, but in my opinion that will never be practical because of the burning of the hand in stopping the spindle to tie up; also because the thread will open up, if the cohesion is not extra good, when the bobbin runs idle on the spindle, or when the ends are broken down. Even without drag wires the tension will overstretch the silk on first time spinning.

The extra cost of machines and operating expense already enumerated for high speed on regular spindles at 15,000 R. P. M. does not promise a higher net efficiency with high speed even with a first class ball bearing spindle.

The most promising field for a ball bearing spindle lies in finding a spindle that will carry a larger bobbin at 12,000 to 13,000 R. P. M., and make practical and economical that speed for second time twisting without flyers, which I will hereafter call third time spinning.

Ball Bearing Drive

The use of ball bearings for the heavy bearings of the spindle belt drive and take-up reduce the power required to drive an average first time spinner about twenty-five per cent.; some actual tests on duplicate machines have shown thirty-two per cent.

Production Per Spindle

The speed of the take-up roll gives the true speed for calculating the production, but it may also be calculated from the spindle speed as follows:

Rule to calculate production from spindle speed: Divide the spindle speed by the number of turns given per inch which gives the number of inches taken up per minute; increase this to hours by multiplying by sixty and reduce to yards by dividing by thirty-six inches; this result, on a 14/16 denier silk, divided by 300,000 yards per pound gives the production on single thread per spindle hour, e. g.

Spindle speed 12,000 R. P. M.
Turns per inch sixteen.
Thread, single.
Size 14/16 denier, 300,000 yards per pound.
We have

$$\text{Production per spindle} = \frac{12{,}000 \times 60}{16} = 45{,}000 \text{ inches per hour}$$

$$\frac{45{,}000}{36} = \frac{1250 \text{ yards per hour}}{300{,}000} = 00416 \text{ lbs. per spindle hour}$$

To produce one pound of thread 14/16 denier in one hour take

$$\frac{1}{00416} \text{ or } 240 \text{ spindles}$$

Assuming that we run the second twist or third time, at 9500 R.P.M. putting in three turns on 5 B and eleven turns on third spinning, the production per

$$\text{spindle hour} = \frac{9500 \text{ R.P.M.} \times 60 \text{ min.} \times 24 \text{ hrs.}}{11 \text{ turn} \times 36 \text{ inches} \times 300{,}000} = 0096 \text{ lbs. per spindle hour.}$$

$$\text{To produce one pound in one hour take } \frac{1}{0096} \text{ or } 104 \text{ spindles.}$$

To produce 1,000-pound per week running day and night, 124 hrs. we determine as follows:

If it takes 240 first time spindles and 100 second time spindles to produce 1 pound in 1 hour to produce 1 pound in 124 hours take $\frac{344}{122}$ or 2.77 spindles.

To produce 1,000 pounds per week we have 1000 × 2.77 or 2770 spindles.

The number of each kind required =

First time 2770 × 70% = 1939 spindles
Second time 2770 × 30% = 831 spindles

Total, 2770

Counting on but ninety per cent efficiency we have:

1939 spindles plus 10% = 2132 spindles
831 spindles plus 10% = 914 spindles

Total, 3046

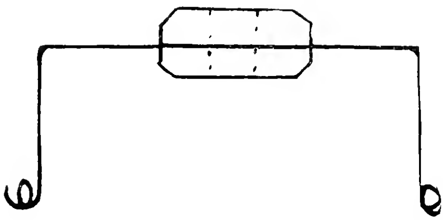


Fig. 42

Speed Second Time Spinner

With the regular drop arm flyers, Fig. 42, 6800 to 7200 are the most efficient speeds. When twisting at a higher speed than 7200 R.P.M. the breaks are excessive and waste and labor cost accordingly.

Humidity is an important factor in this department and should be maintained at sixty-three per cent to sixty-eight per cent relative humidity, the temperature to be kept as low as possible; see Chapter XX on Humidity.

Speed Third Time Spinning

By third time spinning is meant the process of adding the second time twist without a flyer three to three and one-half turns having been already added when doubling on the 5 B's.

The speed of these spindles depends largely on the size of the 5 B shafts; with the No. 78 shaft, head, 2⅛ inches; bbl., 1¼, and traverse, 4 inches, 9500 R. P. M. to 10,000 R. P. M. is about all the spindle will stand. At a higher speed the whorls work loose and spindles soon wear off on point, wobble and cause bad twist. Here is an opportunity for a ball bearing spindle that will carry the No. 78 bobbin, or even larger, at about 12000 R. P. M. No drag wires are then necessary on the thread and a centering eye is all that is needed, as the speed will give enough tension to make the take-up shaft hard enough for good reeling.

Designation of Twist

A very instructive discussion on this subject was given in the Textile World in 1903, which is presented in part as follows:

The direction as well as the amount of twist in yarn exerts an important influence on the appearance of the woven fabric.

By alternating threads of opposite twists in both warp and filling of a plain weave, excellent tricot effects can be obtained running in either direction.

The direction of the twist affects materially the appearance of the cloth woven with a twill or similar weave. In some goods it is desirable to have the twill effect as pronounced as possible; in others the aim is to obliterate all trace of the twill and make the faces smooth. It is necessary that not only the yarn sizes set of the cloth, quality of stock, processes of manufacture, and amount of twist should contribute to the effect desired, but also that the direction of the twist in the yarn be adjusted to the same end.

In the manufacture of plain and fancy twist yarn the direction of the twist is important, both in the single strands and when two or more are twisted together.

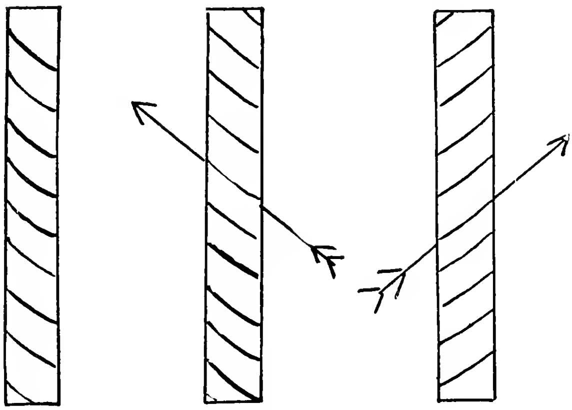


Fig. 43 Fig. 44 Fig. 45

As the direction of the twist is such an important factor in the manufacture of yarn and cloth, it is important that the manner of designating this direction should be uniform.

Unfortunately this is not the case. A thread can be twisted in but two ways, to either one side or the other, and the words right and left have been generally adopted to distinguish these two directions in yarn twists, but the confusion has been caused by a disagreement as to which is right and which is left. The same direction of twist is designated both right and left by different individuals and the divergence is so widespread that it is necessary to determine first what direction is meant by right or left hand twist before a statement in regard to the direction of yarn twist can be accepted.

Our attention was recently drawn to this subject by the necessity of adopting one or the other designations in The Guide to Weaving, soon to be issued in book form. As our desire is to contribute to uniformity rather than to the adoption of the particular method with which we are familiar, we addressed a number of

Fig. 46

letters to manufacturers and textile schools in different parts of the country, asking what was the practice of each in regard to the designation of the direction of the twist of yarn.

The replies showed much confusion, the advocates of each form of designation bringing forward apparently convincing arguments to support their use of the one or the other word. As a matter of general interest we will give the substance of these arguments. In each letter a sample of yarn twisted in the direction shown at Figure 43 was enclosed, and the reference in the replies are to this direction of twist.

Fig. 43. "I have always called such a twist a right hand twist, and wherever I have been employed it has been called the same. I attribute the difference of

opinion largely to two reasons; the user of the yarn in the first place, will naturally take the yarn between his thumb and finger and, decides if it gives more twist by turning to the right with the right hand, it must be a right hand twist, and if he finds he can put more twist into it by turning it on the left, it is a left hand twist. The machine maker and the spinner instruct those who put the bands on the spindles from the cylinder that they must put the leading side of the band to the left side of the spindle or whorl, and by so doing they claim they get what is known as a left hand twist, which from my point of view, is in reality a right hand twist."

Fig. 44. "In reply to your question as to the twist of the sample being either right or left, I will say that my experience is to call it right twist. I was designer in the heavy woolen district of York, England, for ten years, and when ordering would call the twist right, if the twist required was the same as shown in this sample."

Fig. 45. "I call the twist of your sample of yarn left twist, and my explanation why, I can best give by illustrations of a left, Fig 44, and a right Fig. 45 twisted thread. The arrows indicate the direction of the twist.

"In your sample the twist runs as in Fig. 43, from right to left."

"The authors of the French and German textbooks without exception so far as we have examined their writings, agree with the writer of letter No. 45, but the fact that they devote so much space to impressing upon their readers the importance of employing their method and the other fact that textile workers from Europe that have come to this country, vary in their designations of the directions of the twists, leads us to suspect that the practice abroad may vary as in this country.

"At Fig. 46 is shown a rope made by twisting three strands, a, b, c, together. These strands are untwisted at each end for a short distance. If the untwisted strands are to be twisted, it is obviously necessary that the lower strands, a, b, c, must be carried successively to the left. Consequently if reference is made to this act of twisting, the direction of the twist in the rope must be termed left hand, and the opposite twist right hand.

"This line of reasoning answers very well for one end of the rope, but if the other end is referred to, with the observer's position unchanged, the opposite conclusion is reached, as the upper strands, d, e and f, must be carried successively to the right to form the rope, making the twist from this point of view right hand.

"The direction of the strands is indicated by two arrows; if the arrow, g, is selected to indicate the direction of the twist, it is right hand; if the arrow, k, it should be styled left hand.

"These arguments pro and con are certainly not convincing, except as to the need of uniformity, and the question must be settled apparently by no line of reasoning but by the adoption of that method that is in most general use.

"The replies to inquiries lead to the conclusion that the twist of the rope shown at Fig. 46 is more often called left than right hand and we have therefore

adopted this designation. This method has the additional advantage of the endorsement of at least two leading textile schools of the country. We should. however, be glad to hear from any of our readers on this subject, either in support of or opposition to our conclusion."

DIRECTION OF MOTION

By William W. Crosby

Formerly Principal Lowell Textile School, Lowell, Mass.

(The following article by Prof. Crosby, which appeared in the Lowell Textile Journal of March, 1900, shows that the author has recognized the importance of and sought to promote uniformity in the designation of direction of yarn twist. Referring to the article the Professor writes as follows: "In view of the article, Direction of Motion, you will see that we have adopted a standard for naming the twist at the Lowell Textile School, and it is thoroughly understood within the school what is meant. It does not, however, correct the situation outside, and those mills that name their twist to the other hand would probably have some criticism to make, but it is obvious that we must come to a standard somewhere."—Ed.)

In naming the direction of a given motion there must, of course, be assumed some datum point, line, plane, or combination of two or more of the three. If you wish to express the linear velocity or speed of a railroad train, you do so by stating the number of miles the train recedes from a given point, in or beside the track, in an hour; but the same numerical quantity might equally well express the speed with which the train approaches some other point beyond. This leads us to define our motion not merely for velocity but also for direction; this we may name to the right or the left, we meanwhile standing beside the track, if another person be facing us across the track, the train which has gone to our right will have gone to his left; thus we see that in naming such a motion, one particular point must be chosen as the reference point.

This same principle must be borne in mind when naming the direction of rotation of a shaft; for a given shaft running in a fixed direction will be named differently by persons facing one another, standing at its opposite ends. Motions upward, to the right, right-handed, "with the sun" "clockwise," or with the hands of a watch are considered as positive (plus) and are effected with the + sign: motions downward to the left, left-handed. "against the sun," "counter clockwise" or against the hands of a watch are considered negative (minus) and are effected with the — sign.

In this way we can fix exactly the various motions with which we may wish to deal, and their magnitudes. A right handed screw is defined as one with threads so cut that when it is held pointing away from the observer and turned in the direction of the hands of a watch, it will enter the nut; if such a screw be viewed from the side, the direction of the threads is upward to the right.

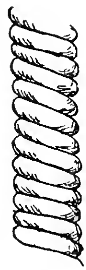
In naming the twist of yarns there seems to be considerable indefiniteness and confusion; for one person will say that the twist should be named to correspond with the screw where the direction of the fibre in the yarn is the same as the screw threads; another says that the direction of the spindle that spins the yarn should be the criterion; again it is said that the twist should have the same name as the motion that produces it, named looking toward that end of the strand where the twist is applied.

If you twist two strands of yarn together, turning right-handed while another person holds the other end stationary, the resultant strand will be right twist; if now the other person twists his end right-handed as he views it, more twist will be put in; if, while you turn righthanded he turns left-handed, as he views it, the yarn will merely revolve and no twist will be put in.

It will be noticed that the direction of the strands in a bit of yarn with right twist as named above, is directly opposite to the threads of a right-handed screw. This would seem to cause some confusion, as in the case of those who name the twist from its correspondence to the right or left-handed screws, but we can find some element of logic in this, for the word "twist" is essentially a verb and when we have named a certain strand as having a right twist, we have named it to correspond with the motion that produces it, but the word "screw" is primarily a noun, the verb being a secondary idea and that is named with reference to the use of the article itself.

Left.

Fig. 47



Right.

Fig. 48

To sum up, then, right twist as applied to yarns is that twist which is produced by turning the end of the yarn that is toward you, the other fastened to a distant point, in the direction of the hands of a watch as the watch is held in front of the turning strand, its face being toward the observer.

Just why that part of the body that is toward the south when one is facing east should have been called "right," I cannot say, unless other than it should have some name it were because it is usually the stronger and abler of the two; but the fact remains that it is so named and we must adapt ourselves to it.

The practice among silk throwsters and manufacturers in America is to call Fig. 47 left hand or reverse twist, Fig. 48 right hand or regular twist. French twist testers are built with two dials, the one used for left twist is called "Filage" and the thread opens when turning the crank towards the body, the direction of which is shown by Fig. 47 or left hand twist, same as regular first time. The other dial is called "Filato" and the thread opens when the crank is turned away from the body as shown by Fig. 48 and is called right hand or the regular second time twist.

Nearly all American twist testers are built with but one dial: the reverse or left twist is obtained by turning the crank toward the body, the right hand on regular twist by turning the crank away from body.

In mill practice the direction of twist is determined in the following manner on the thread:

Take one end of thread in left hand, the other in right hand and hold it in a horizontal position; the thread opening up when turning away from the body, with the right hand, is left twist, the thread opening when turning towards body is right twist.

On the spindle: When standing over a spinning spindle, the spindle running clockwise is making left twist, the one running anti-clockwise, right twist.

On a bobbin: In examining a bobbin place the small hole on top, then the thread paying off clockwise is right twist, and that paying off anti-clockwise is left twist.

In doubling: In doubling left twist place the small hole towards the right; right twist, place the small hole to the left.

Spinning Parts

Skilled spinners can tend anywhere from 600 to 1,200 spindles at 12,000 to 12,500 spindle speed, depending on the class of stock, the air condition of mill room, the kind of tension wires used and the care taken in winding. Long knots, cotton bands, waste, ridgy bobbins, bobbins wound convex with a slow transverse, bobbins wound with a rough spindle head, causing them to jump and the threads overlap each other, all add to the spinning breaks. The depth of bobbin and length of traverse must also be considered.

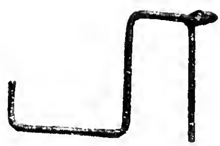


Fig. 49

On a winder bobbin holding 30,000 yards, filling up with fresh bobbins, as they empty on the spindles, causes one-third of the work on silk running well, or showing about 15 X breaks, or breaks per 300,000 yards. (See Chapter IX on Reports for further details on X breaks.) In laying out new plants, if these bobbins are made the maximum size that the type and spacing of spindle will permit, then it will make it possible to run a greater number of spindles because of reduced time in replacing empty bobbins.

Precautions, however, must be taken so as not to get the traverse too long or bobbins too deep and increase the breaks.

Slack twist causes the thread to dye bright, making streaks in cloth; shafts also are wrapped softer and cause uneven doubling.

The slack twist may be due to spindle belt riding on whorl, spindle worn down and riding on step, dry spindles, dry spindle holder, causing spindle to stand away from belt, and oily spindle belts.

Fig. 50

Long knots and snarls frequently catch in doubling and break down. The snarls are caused in tieing up slowly and in starting up the machine without first rubbing out the kinks. They also make a bad corkscrew for a short distance on the thread. Shaft run up on ends pay off faster on doubling and throw in a loop. Crossed threads cause very uneven doubling, causing loops or corkscrews. Chafed silk happens when the shaft is held back by the thread and roll rubs on the silk or by shaft running several hours on rolls when ends are broken down. The thread becomes very tender and looks flossy.

Double ends are caused when breaking down end flies over into running thread and goes up double.

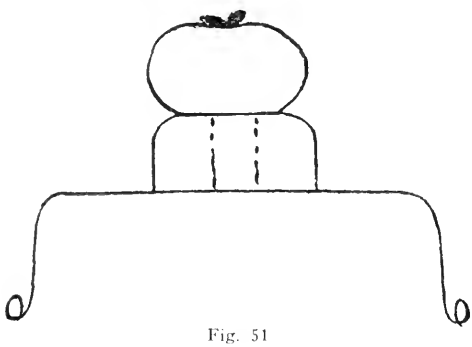


Fig. 51

On second spinning the defects are singles, corkscrews, bad knots, wastes and double ends, slack twist, hard twist and crossed threads.

Singles show on the dyed thread as flossy ends, frequently called soft ends. The reason for this is that the right twist takes out the left twist and leaves the thread with but a slight tram twist.

Corkscrews are caused by not getting the ends together and they run until they come to a knot and then break down.

Oiling Spindles

With good spindles and proper care they will run two months, day and night, to an oiling. When the power is limited care must be taken not to oil all the spindles at one time, as the increased power required after fresh oiling may overtax the power plant. This can be partly prevented by heating the spindle oil before using.

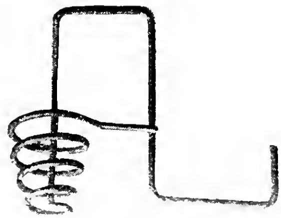


Fig. 52

Flyers, Drag Wires and Tension Wires on First, Second and Third Spinning.

The Lovatt drag wire on first spinning as shown by Fig. 49 when one inch long gives three wraps on the down wire; the tension is light and is a good drag to catch waste. The wraps are uniform when the thread pays off the top of spinning bobbins as well as when paying off bottom; but when this drag is over one inch long then when the thread pays off the top of bobbin it double balloons, and gives the thread two extra wraps, frequently so tight that it breaks down the thread.

To overcome the extra wrapping around wire the design shown by Fig. 50 is being used, which gives as many wraps as there are coils of wire, but they do not catch as much waste as the Lovatt wire.

The number of coils is determined by the spindle speed; the lower the speed the greater the number of coils, the purpose being to make a bobbin hard enough to give good doubling and find ends readily.

On second time spinning the drop arm flyer is generally used as shown by Fig. 42.

The figure eight flyers as shown by Fig. 51 are used only on heavy thread, or heavy twists when the thread over-swings the speed of flyer and breaks down. With flyers only a centering eye is used.

On third time spinning Fig. 52 drag is used made up for right hand twist.

Defective Work

On first spinning we have slack twist, long knots, snarls, shaft run up on ends, chafed or what is commonly known as burnt silk, crossed threads and double ends.

PART III—CHAPTER XI

ORGAN DOUBLING

The following are the various methods of doubling organzine that the author is familiar with and he proposes to show the merits and demerits of each system as they have occurred to him.

Jack Pin Doubling. This is also called Vertical doubling and is shown by Figure 53. With this process a fibre shaft is used on first spinning with a loose pin, which is removed when shafts are doffed. These shafts are then placed on jack pins and thread is drawn from the side same as regular tram doubling.

This process presents many opportunities to cause uneven doubling and make corkscrews, which are as follows:

Mechanical Causes of Imperfect Doubling and Remedies

A. Excessive speed causes fine threads to overstretch or become permanently elongated, contract differently and make a cockled thread; it also overruns and throws in a loop. The speed should not be over eighty-thread speed with frictionless bobbins.

B. Fibre shafts running on jack pins the full length of shaft, cause too much tension. This can be remedied by using frictionless shafts and oiling jack pins weekly.

C. Warped fibre shafts cause edges of shaft to drag on end of pin bracket.

D. Soft shafts due to slack twist.

E. Various size shafts cause a different tension on threads. This may be avoided by keeping the thread speed between empty and full bobbin not over thirty yards apart.

Manual and Partly Mechanical Causes of Imperfect Doubling

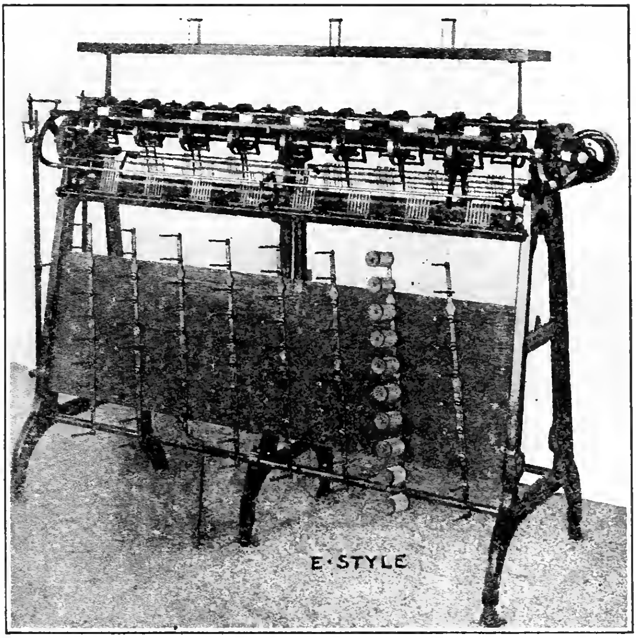
F. Fibre shafts run up on side causing them to overrun when thread reaches the greater diameter, and throw in loop. To avoid, watch guides on first spinning.

G. Waste on pins causes bobbins to fit tight and increase the tension on thread. This can be largely avoided by cleaning pins every time lots are changed.

H. Dry jack pins increase tension on one or more threads. These should be oiled once a week.

I. Crossed or looped threads. This is done by careless hands on first spinning.

J. Ends not brought together properly on take-up bobbin before tieing up make the most common and serious defect that can be made every time an end is tied up. It not only causes uneven doubling but causes increased breaks on the second time spinning, as the thread will break down at every knot where the threads are not properly brought together before tieing.



VERTICAL DOUBLING FRAME.

Fig. 53

This is the most economical method of doubling, as a bobbin always pays off its side with less breaks than over its head. The thread does not kink and steaming of the first time shafts is unnecessary.

With fibre shafts, cork or treated leather rolls must be used so as to give enough tension to break down the thread when it catches in drag wire and holds back the thread.

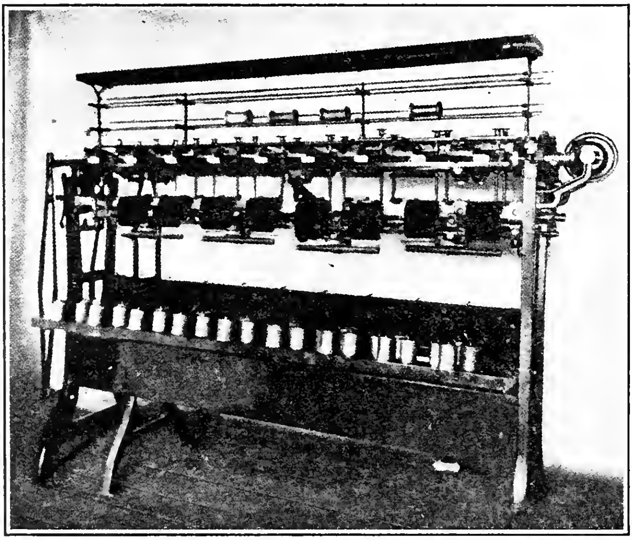
Figure Eight Flyers

With this process a solid pin iron head shaft is used on first spinning and the flyer is placed on a block having a short stud and nut. The shafts must be steamed before doubling so as to overcome the kinks.

It is the most troublesome and expensive method in use; the difficulties are as follows:

The flyers cut frequently and must be rewired; blocks wear out elliptically and wobble; arms are constantly out of shape and give either a loose or tight tension; waste and gum collects under and on the pin of the flyer, which requires frequent cleaning and oiling.

The only advantage that this system has is that a solid pin iron head can be used on first spinning, and because of its weight a paper roll may be used.



NEW MODEL DOUBLING FRAME

Fig. 54

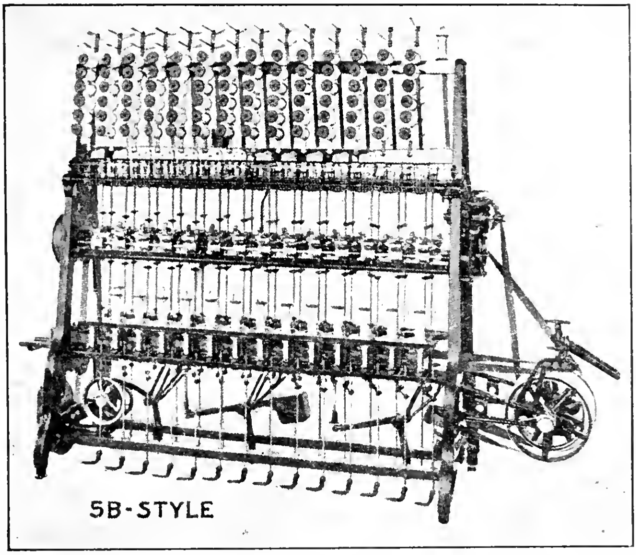
Waste does not accumulate on pins of shafts same as on loose pins. Time of doffing is much less than with loose pins.

The amount of defective work is greater with this method than with the jack pin doubling.

Plush doubling. This method was introduced by H. D. Klots and gives the most uniform and even doubling yet devised, but the labor cost is greater than the jack pin method. It consists of running the thread over the head of shaft using a cap similar to that used on the reels and getting a tension by drawing the thread over a girth covered with mohair plush. See Fig. 54.

Two hundred thread speed may be run with excellent results with organ spun or long second time shaft. At the speed named, a slight increase on the tension breaks down the thread and prevents uneven doubling. The tension is so light that only the very fine ends cause corkscrews. When using a long

second time shaft for the first spinning the maximum efficiency is obtained. There is practically but one way to make corkscrew and that is by failing to get the two threads together on the take-up bobbin.



COMBINED DOUBLING AND SPINNING FRAME FOR TRAM.

Fig. 55

Fourth. 5B Doubling.—This process was originally designed to double and twist tram and was first applied to the throwing of organzine by Ferenbach and McFarlane, then of the Wilkesbarre Silk Co. It consists of using the jack pins for doubling and taking up on a down spinning spindle putting in from two and one-half to three and one-half turns per inch and adding the rest of the second time twist on a regular spinner without a flyer; it is named third time so as to distinguish it from the regular second time process, which adds all of the second time twist with a flyer. (For 5B machine see Fig. 55.)

The opportunities for uneven doubling are the same as A, B, C, D, E, F, G, H, J and K of jack pin doubling. In addition to the above there are three other conditions to be guarded against.

L. Loose threads hanging down from supply shaft kept on upper pins and catching in running shafts, cause uneven tension on thread.

M. Ring of thread on feed rolls causing one thread to run on top of ring and feed in faster than the one on the bare roll.

N. Adding too low a twist on 5B's, causing loops. This is caused partly by the slack thread not twisting in as the thread takes up but moving along until it can go no further and then making a loop. It may also be caused by the thread

not being together enough and on third time one thread catching on the head and causing a loop. From two to three and one-half turns are being added on 5B's. Three and one-half gives the best results and loops are rarely seen when that amount of twist is put in.

O. With the regular tram traveler and ring (see Figs. 60-61) the tension is too great to run faster than 5100 R.P.M. of spindle. Even at this speed the breaks on 12/14 and under are excessive, due to the heavy traveler.

P. Low life of traveler, cut on ring in forty-five hours' run.

Q. Travelers flying out caused by waste going through and causing a sudden jerk. At times the traveler also flies out and pricks the 5B shaft, cutting the shaft rather deep.

This process I consider the most ideal for throwing organzine, as with the proper remodelling it can be made the most dependable method on all kinds of stock; the quality of the organzine made superior to the 5C and the cost reduced to that of the 5C, which now leads all other processes, **on good silk,** in point of labor cost.

It can be converted to tram or crepes with the same help and standardizes the method of doubling all classes of threads, which is a great factor in point of efficient operations.

The principal point of merit is the fact that the doubled threads are always together and this endless source of uneven doubling is entirely prevented. It also avoids the use of flyers on second time spinning and prevents the second opportunity of getting ends apart. A high speed can be run on third spinning and a greater part run.

Before we consider the plan of remodeling let us first consider the nature of the silk thread and the various conditions we must adapt ourselves to in order to make the process a complete success.

In naming the various causes of uneven doubling I desire to state that I am fully aware that several of those named do not of themselves make a corkscrew that is marked enough to affect the grade of the organzine, but it will be readily understood that frequently several of these conditions get together and an objectionable thread is then made. In looking for corkscrew it must also be remembered that the thread must first be steamed so as to cause contraction when the corkscrews are only fully developed. (This effect is always produced in boiling off.)

Fine and coarse threads are the two serious conditions we must contend with; the very fine, which are from three and one-half to six denier can be broken out in winding and first spinning, but when these are removed only the very fine part is removed and made to waste; and the operative ties up just as soon as the thread is strong enough to stand tieing the knot, which is near seven to nine denier. If too heavy a tension is used then the threads of seven to nine denier, that are not removed, are overstretched and when doubled with a regular thread, the contraction after boiling off is different and a corkscrew results.

There is therefore a limit to the tension that may be used in winding and first spinning to improve the thread in throwing organzine. In doubling, the

lighter the tension the more even will be the doubling. We must adapt our speeds and methods to the resistance of overstretching that a thread of seven to nine denier has. We must also consider the contraction of the silk thread on the doubled bobbin. The air change between day shift and night, when the mill is closed, is considerable and brings about constant expansion and contraction of the silk thread. A tightly wrapped bobbin shrinks more than does a loosely wrapped bobbin, therefore a thread doubled at too high a speed or with too heavy a traveler on 5B in the first place overstretches the fine thread; in the second place the regular thread contracts more than the overstretched fine thread and a more or less cockled thread results. When two threads are doubled together of uneven diameter and the proportion is one to two, a slight corkscrew results, even with the most even doubling. When the proportion is one to three then the corkscrew is very marked. In other words if you double an eight-denier thread with a sixteen denier a slight corkscrew results, but when you double an eight denier with a twenty-four denier a very marked corkscrew is made even with the most perfect doubling.

I desire to point out that corkscrews are not always the fault of the throwster but are frequently the fault of the unevenness of the raw stock; this unevenness no method in throwing will improve very much, but it is the duty of the throwster to do the very best with the thread he gets; and his methods must be as near perfect as possible; and to guarantee results, he must prevent the manual defects as much as possible. As has been shown an eight and sixteen denier doubled together make a slight corkscrew, but if the tension is uneven and a heavier drag is found on the eight denier, then the corkscrew instead of being passable will be objectionable; therefore with these conditions to contend with we will present the following plan for remodeling the 5B process of doubling organzine, which has been made a success.

First use a wide second time roll on first spinning, covered with treated leather, first covering the rolls with paper tubes, then turning them down true and applying the leathers afterward.

The benefits of these changes are as follows:

A. Increased yardage on shafts, less doffing on first spinning, meaning less waste and greater spinning and less filling up on 5B.

B. Twenty-five per cent. less breaks on first spinning, meaning less waste and greater spinning part.

C. Less shafts run up on side. This fault on first spinning may be due to the cork or paper rolls being worn off on side and needing recovering, or guides out of place and needing readjustment, but with the narrow first time shafts this trouble is largely due to the rolls not being made true and having a high side which causes the shaft to run up on that side when shafts get over three-quarter full. Taper shafts may also be made when shafts run with thread broken down and end pays off backward and wraps around pin, causing the pin to become thicker on one side. This cannot happen as frequently on the wide rolls, as the thread breaks when paying off over three-quarters the width of shaft.

D. The advantage of changing machines to third time and working hard twists.

Second. First time shafts to have tight pins so made that the shafts can be placed on jack pins on 5B's and give the minimum friction. This can be done by making a steel gudgeon with a one-quarter inch bore and fastened under both heads of shaft extending out one-quarter inch so as to serve as a pin on first spinning and a frictionless bushing on 5B's.

This will overcome the trouble with loose pins working out and shafts running up on side, or running against traverse rail.

A higher speed can be run, as the tension is considerably less.

No trouble with warped shafts riding on end of pin bracket.

The head of shaft to be two and one-half inches, barrel one and five-eighths inches; the difference in speed between empty and full bobbins with this bobbin will not be enough to make the difference in tension perceptible.

Third. Replace the regular tram rings with two and one-quarter inch cotton double flange rings, special silk design, and use 9/0 to 12/0 round wire travelers.

The life of these travelers is from 100 to 120 hours, as compared with forty to forty-five hours on the regular tram. This will reduce traveler cost, prevent them flying out and reduce the breaks even at faster speed.

To prevent the thread from supply shafts getting into running shaft a shelf can be made in front of machine and shafts placed there on boards. Loops can be almost entirely overcome by putting in three one-half turns. Speed: The maximum spindle speed to be not over 6,100 R.P.M., as a higher speed gives a short feed roll life.

Use Lovatt drags on first spinning so as to catch all waste and bad knots and improve doubling.

The principal defects that must be guarded against are reduced to but five, all of which can be carefully watched by foreman.

F. Soft shafts due to slack twist, causing slack tension on first spinning.

I. Crossed or looped threads.

M. Thread running on ring of waste on feed rolls.

G. Waste on pins. Single threads.

The feed roll has quite an evening up action on the threads and unless D. I. and G. are very extreme they do not make a corkscrew.

The manual defects are reduced to the minimum and if the first time work is perfect, or even only of the average class, the organzine produced by this process averages more perfect than by any other process known to the author.

(The throwing of tram on 5B's will be considered in a later chapter under tram throwing.)

Care of 5B Machine

This machine is more complicated than an ordinary doubler and proper care must be given if the best results are to be obtained.

Oiling. The rings should be oiled daily with a good class of vaseline or a stainless class of non-fluid oil. The best plan is to put the vaseline in the

palm of the hand and then apply it to the rings with the forefinger. It is important that the rings do not have too much oil and are kept cleaned so that there will be no accumulation or dirt or grit inside of the rings, causing the silk to become stained.

The spindles should be oiled every three months; to oil, remove the spindles and insert the oiling spindle and carefully fill reservoir, taking care not to get the oil on the outside where it will come in contact with belt; then remove oiling spindle and replace spindle very carefully. If dropped suddenly the oil will be forced out and get against whorl and belt. Be very particular to put spindle back in its own step.

It is very important that spindle belts be kept free from oil and grease. When they do become oily, absorb the free oil by holding a piece of chalk or better a piece of whitening against the running belt until all of the oil is absorbed, then scrape off with a knife. Repeat this operation until the belt is thoroughly freed from oil.

In adjusting spindles care must be taken not to drive in one spindle too far and push the belt away from the next spindle. They should be adjusted in sets of two and care taken as to the location of the idler and its effect on the spindle.

Spindle belting should be uniform in thickness and when it becomes stretched out too thin then the belt should be removed and worn out on first time spinning.

See that the rings are adjusted so as to bring the spindles exactly in the centre; to do this bring the traverse about one-third of the way up, then place a bobbin or adjusting ring on the spindles, loosen the screw that holds the ring to the rail and adjust it so that it first clears the bobbin or adjusting ring evenly on all sides, then tighten the screw. The rings must be fastened perfectly level on the rails.

Feed Rolls

These must be kept perfectly smooth and free from sharp edges caused in removing waste. Rough rolls can be entirely avoided by cutting a one-eighth inch groove across the face of roll and running scissors in it when cutting off waste.

Style of Ring and Traveler

Use a two and a quarter inch No. 2 double flange ring, special silk design. With proper care they will wear from three to four years. With fine sizes use a 12/0 round wire traveler No. 2 circle, on 13/15 or over, use a 9/0 traveler. These travelers will cut in about 200 hours at 5,800 spindle speed, putting in three turns per inch.

Waste should be removed in first spinning so as to prevent it throwing the thread out of traveler and running a ring of loose thread on top of take-up shaft, frequently swinging over and breaking down the running bobbins on one or both sides of it. The ring has been designed to prevent this springing out but it cannot be entirely overcome unless the waste is caught in first time spinning.

Production per Spindle

This is determined from the spindle speed as given in Chapter XI, and is as follows, on various speeds and turns on two-thread organzine 14/16 denier.

5000 R.P.M.	3½	turns	.01576	lbs.	spindle	hour.
	3	"	.0185	"	"	"
	2½	"	.0222	"	"	"
5500 R.P.M.	3½	"	.0174	"	"	"
	3	"	.0204	"	"	"
	2½	"	.0244	"	"	"
6000 R.P.M.	3½	"	.0190	"	"	"
	3	"	.0222	"	"	"
	2½	"	.0266	"	"	"

Number of Spindles Operated per Hand

This varies from 200 to 300 spindles, depending on the thread speed, working qualities of the silk, size of first time shafts, and air conditions in mill.

PART III—CHAPTER XII

COMBINATION SPINNERS FOR THROWING TWO-THREAD ORGANZINE

There are three systems in general use; the Tynan, consisting of spinning, doubling and twisting in one operation; the Spinning Doubling; consisting of spinning and doubling on one machine and twisting second time on a second time spinner with flyers; the 5C consisting of spinning, doubling and twisting in one operation.

The spindles of the Tynan system are driven by bands and this appears to be one of the chief reasons for the machine not being extensively used. The objections to band driven spindles are that the bands are subject to atmospheric changes, becoming tight in dry and slack in moist weather. As they wear out they generally become slacker and unless constantly followed up will cause slack twist.

The Spinner Doubling process has never been very extensively used, first because it is not efficient in operative cost nor in quality of work produced. A number of plants formerly operated have been changed over to single process. The machine consists of a double row of spinning spindles and spins the first time twists while it takes up the thread through two drop fallers over a plush cushion as two thread on a spinner bobbin and thus doubles while it spins. A spinner bobbin when three-fourths empty has considerably more tension than a full spinner bobbin and when fine threads are spun, if the empty bobbin happens to be fine and the full bobbin coarse, then the fine thread in passing over the plush girth or tension cushion, placed there so as to give enough tension to hold the drop fallers up, overstretches the fine thread and a corkscrew is made. If the plush tension girth is lowered so as to make the tension right, for nearly empty bobbins, then it is too light for the full bobbins, and causes the drop fallers to knock off, stops the take-up bobbins and the two threads twist off or break down the threads. When Lovatt drags are used to catch the waste then the waste breaks down the thread at drag and frequently holds up the drop faller, causing the other thread to continue running and makes a single. When the thread breaks down and bobbin stops off, then the bobbin unwinds on knock-off lugs and covers them with silk thread and, if not cut off prevents the knock-off from working.

Every time an end is tied up the threads must be brought together, otherwise they make corkscrews and will also break down when they get to the knot on second spinning.

The second time spinners may also make corkscrews if ends are not brought together when tieing up.

Short singles can also be made if hands do not draw back single thread on take-up shafts. Almost every time an end breaks down, one thread breaks and runs a band on spinner bobbin, while the other thread continues running on take-up shaft until the band is tight enough to break down the thread.

With even silk and good help a good class of organzine can be thrown on these machines, but with the average help the work is inferior to the 5C process or the single process with plush or 5B doubling. Help object to working on them because it requires considerable skill to operate a full part, and requires from six to eight months' time to become an experienced Spinner Doubler. The low production of the machine, since it spins and doubles in one process, requires a great number of hands, and with the cheaper class of labor that is generally employed in throwing plants it is a difficult matter to get a sufficient number who will work at low pay long enough to become skilled when even then, at present price of labor, it is not sufficient to induce help to remain at work except in isolated towns where no other work is to be had.

5C Process

This machine is shown by Figure 56 and is without doubt the most efficient machine to throw two-thread organzine with a silk thread of extra grade or

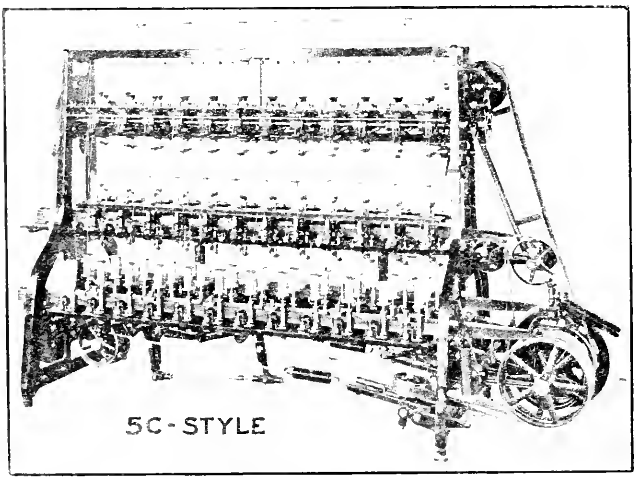


Fig. 56

better, but on low grade stock the single process with 5B doubling produces a better class of organzine. The merits of the system are: first, with skilled help and good silk the labor cost is cheaper than any other process; second, as the

threads are twisted together as they are doubled, no threads need be brought together as is the case on spinning doubling or on regular doubling, and this cause of uneven doubling removed; third, hard bobbins and very fine threads are the only two causes of corkscrew and they must be extreme before the corkscrew becomes very marked as the feed roll has an equalizing effect; fourth, the twist is set in adding the second time twist and there is no curl or kinks on finished thread, therefore, reel flys need not be steamed to set the twist. The objections to the process are that they make a great many singles, caterpillars, hard twist, slack twist and help object to work on them in a mill having the single process; the turnover of help also is great because of the time required to become experienced workers and earn full rate pay. On poor silk the defects are numerous and waste so excessive that it becomes necessary to select only the best lots for this process. We will consider the objections in the order named:

Singles are caused principally by waste holding up the drop faller, fallers sticking against wire rest and drop fallers not in proper order. I have only found a partial remedy for waste holding up the fallers and that is to use a No. 575 porcelain hook, instead of the No. 346 hook. The fallers can be prevented from sticking against wire rest by bringing this wire out far enough and cleaning it occasionally. The drop faller mechanism is of good substantial construction and if kept in order can be depended upon to knock off. Caterpillars: A caterpillar is a ring of thread around another and made when one of a double thread breaks and is pushed back on the other, resembling a caterpillar. They are caused by cut travelers, rough, worn and broken rings. If the travelers are changed every 124 hours, the rings greased every ten hours, the life of the ring will be at least 10,000 hours on one flange and with double flange rings about three years' service, 124 hours per week, can be obtained before any trouble should be experienced with caterpillars.

Hard twist is caused by the friction feed rolls when grease or oil gets on the friction surfaces and causes them to run slow; on the geared feed rolls when the feed rolls are set too high and jump the gears and when the two-inch feed roll driving gears get loose on shaft. To prevent the friction surfaces becoming oily some reliable person should attend to the oiling of the roller shafts and use only a hard grease. The other defects are mechanical and can be readily remedied.

Hard twist is also made when the threads are not wrapped around the feed rolls often enough, or the thread is not fed in fast enough. Hard and slack twist on 5C is more serious than on the single process because both the first and second twist is affected.

Slack twist. This is caused when one spindle is driven too far against the spindle belt and holds the belt away from the other spindle, and when the spindle belt becomes too oily. This can be prevented by setting the spindles in pairs and cleaning the spindle belts by first chalking them with ordinary mill crayons or better still lump whitening. It will be observed that the machine requires constant attention by a competent and experienced man, and therefore a few in a mill are not profitable, nor is a mill equipped wholly with them an efficient layout. In deciding upon the proper number to install in a plant, the first considera-

tion should be given to the percentage of high grade stock that is run. Second, an equipment that will be large enough to warrant the employment of a good mechanic to take care of them properly, or few enough so a good foreman can look after the repairs and also oversee the help.

If the 5C Spinners are kept in first class shape and the parts reduced to that which a hand can keep going, why can they not be operated on low grade stock just as cheaply as the same silk on the single process?

First, because every time a thread breaks you affect three processes; on the single process the defects can largely be removed on the first time spinners, and that will reduce the breaks in the doubling and second time spinners.

Second, to tie up a break on the 5C requires about one-third longer than on first spinning, so that while on the single process there is more doffing and filling up to counterbalance this, it is not enough to make up fully for the loss in time, since all the breaks occur in one process.

Third, it is the practice to run the machines between shifts and during the noon hour, and where this is done too many spindles are idle and the belt is held away from the spindle, and, unless spindles and stop whorls are properly adjusted, causes slack twist. If machines are stopped during this period then the head end gets hot, if the loose driving pulley is not kept properly oiled, and there is quite a loss in production and an increase in cost.

Fifth, actual working results show that even with the best of help, when running low grade stock, singles and slack twist are excessive; also that on good stock the operating cost is the cheapest, but on low grade stock it is the highest.

Travelers and Rings

1 13/16" and 2" rings are used with No. 1 flange. I understand that 2¼" rings are also used with good success. On the No. 1 flange a 15/0 traveler ⅝" circle gives the best results. If the ends fly out more than appears necessary then a smaller circle traveler should be used. If the flange is thin then a ½" circle gives the best results.

The travelers cut in about 130 hours' run, so it is advisable to change them every week on a day and night run, or every two weeks on a day run only.

Care and Oiling

See rules given for 5B machines, Chapter XI.

Horse Power

The horse power required at 9,000 first time spinner speed is about 2.50 HP per 80 second time spindle machine.

The best results are obtained at a first time spindle speed of 9,000 to 9,600 R. P. M., and second time speed about 7,875 to 8,400 R. P. M., with 16/14 turns.

The spindle speed can be determined by multiplying the speed of the head end shaft by the following constants:

First time, 14.77 time R. P. M. of head end shaft. 12" belt pulley, 13/16 whirls.

Second time, 12.93 time R. P. M. of head end shaft. 10½″ belt pulley, 13/16 whirls.

The theoretical production of the machine at 9,000 first time on two-thread organzine is as follows:

16/14 turn	14/16 denier	.006	lb. per spindle hour
" "	13/15 "	.00559	" " " "
" "	12/14 "	.00519	" " " "

80 spindles 14/16 denier 10 hours= 80×10×.006=4.80 lbs.

Spinning Parts

An experienced spinner can tend from 320 to 400 spindles on extra grade of silk. It requires from four to six months' time to become a skilled 5C spinner.

The following is a comparison between the different methods of throwing organzine as to the quality of work, labor cost, etc.

The quality of organzine produced by the various methods named I find in the following order:

	Best
5B doubling adding 3½ turn, with steel Gudgeon first time fibre shaft.....	A
5C combination process	B
Plush doubling solid pin iron head shaft drawing thread over head, using cap	C
Figure 8 flyers, drawing thread over head..........	D
Spinner doubling, combination spinning and doubling..........	E
Jackpin doubling, drawing thread over side from loose pin fibre shaft, on ordinary jackpin doubler	F

The comparative cost per pound on equipment, taking in machinery, shafting, belting, floor space and general building requirements are as follows on day only and day and night equipment:

(These are only nominal values, however, the difference between each class represents a true relative value).

	Day only	Day & Night
Spinning doubler process	$1.00	$0.52
Single process, single deck spinners d ubling on 5B adding 3 turns, twisting without flyer..........	1.16	0.75
Single process, double deck, spinners doubling on 5B adding 3 turns, twisting without a flyer, short first time shaft	1.00	0.67
5C combination process	1.15	0.59
Single process, doubling on plush doubler and twisting with flyer	1.25	0.69

The comparative cost per pound for labor and adding twelve per cent per annum for interest and depreciation on machinery, building and bobbins, is as follows:

(These are only nominal values, however, the difference between each class represents a true relative value).

	Day only	Day & Night
Spinner doubling	$1.00	$0.952
Single process, single deck 5B doubling..........	0.989	0.923
Single process, double deck 5B doubling.........	0.96	0.914
5C combination	0.914	0.822
Single process, plush doubling	1.11	1.01

It will be observed that while the spinning doubling is the lowest in cost of equipment it is next to the highest in cost per pound and stands fifth in quality of work and is only suitable for extra grade of silk. The 5C combination, while it stands next to the highest in cost of equipment for a day proposition, is the lowest when including labor cost per pound, stands second in quality of work, but it must be remembered that it is only suitable for throwing extra grade of silk. Please note that no allowance was made on the single process, for the fact that the lower grades were run on the single process and that when comparing the process on the same quality of raw the standing of the single process, single deck, would be about, day only, $0.94 day and night $0.85.

These comparisons were made under good labor conditions, and before the war prices.

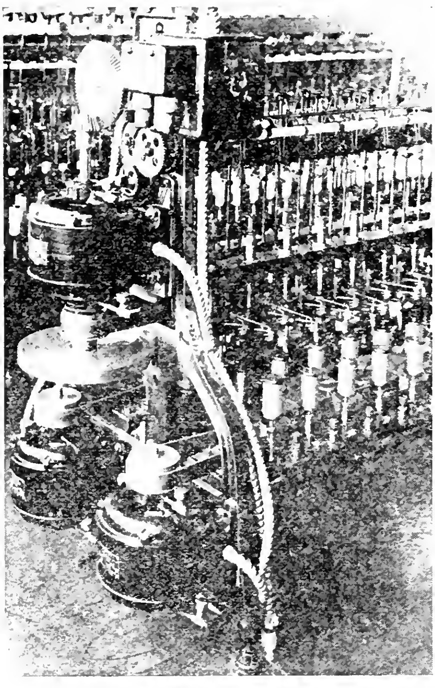


Fig. 57

Figure 57 shows the most modern method of driving the 5C and is presented by courtesy of C. T. Guildford, General Engineer of the Westinghouse Electrical Manufacturing Co., and consists of the following:

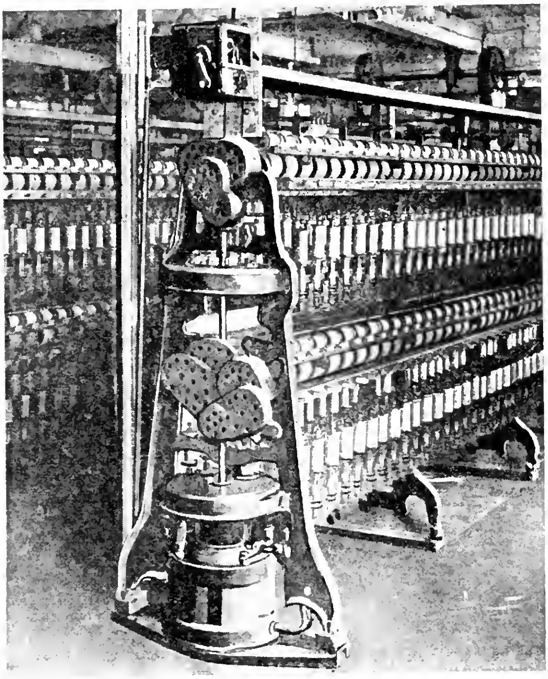


Fig. 58

A one H.P., 1760, R.P.M. ball-bearing type of motor is mounted to drive each deck. The two motors on the lower deck drive with shaft extension at the top, and the spindle belts are driven direct from the motor pulley. The upper motor drives the upper deck from a lower shaft extension of the motor, and the spindle belt drives direct from the motor pulley. Below this motor pulley on the motor shaft is a flywheel, which serves to carry over the upper deck for a little longer period of time than the running of the lower deck when all three motors are switched off on shutting down the frame. The purpose of this is to take up the slack of the yarn, and prevent kinks. The upper motor has an upper shaft extension which drives, by beveled gear, the feed rolls. All three motors are connected to a quick make-and-break switch, with overload and no voltage trip. All three motors start simultaneously when the switch is thrown in, and stop when the switch is thrown out or the voltage on the line drops to a point which trips out the no-voltage release. The two motors on the lower deck come to rest from seven to twelve seconds sooner than the motor on the upper deck. The time interval given by the upper motor to take up the slack and prevent kinks is

governed by the weight of the flywheel. This flywheel is made in sections so that added weight can be given to it in case a longer period of time is necessary between the stopping of the lower and the upper motor. The slack of the spindle belt is taken care of by idler with weight and rack.

The advantages of this drive are:

(1) There is considerable saving in the length of spindle belt required for the frame.

(2) All the cross-head drive with its quarter turn belts, idlers and brackets are removed, thus making a very simple mechanical application.

(3) The speed of the feed rolls bears a constant ratio to the speed of the spindles, because it is driven by a gear from the same motor shaft.

(4) Belt slippage is reduced to an absolute minimum since the motors are grease-lubricated ball-bearing, and therefore there is no oil to get on the spindle belt, as is the case with the usual oil lubricated cross-head with its various idlers which have to be oiled freely. On this account spindle speed remains constant.

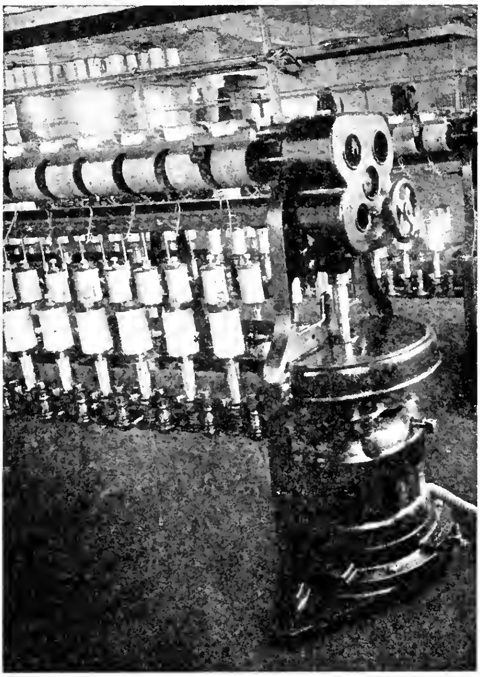


Fig. 59

Figure 58 shows the new drive for the Atwood Style C double deck spinner. The motor is a five horse power, 850 R. P. M., coupled direct to the vertical shaft, which drives the take-up roll and both decks of spindles. The lower bracket of

the motor rests on the floor, and has extensions on both sides to take the feet of the end stand of the spinner. This end stand is bolted to the motor lower bracket with the stud bolts in the feet of the end stand. The motor is also braced at the top by steel straps connecting the upper bracket to the end stand. Thus, when the motor is set in position, being plumbed and leveled, it is an integral part of the end stand and cannot get out of line. The lower spindle pulley is split and serves as a coupling between the motor and the vertical shaft. The upper spindle belt pulley is also split. This feature makes it convenient when speed changes are necessary, as the pulley is removed without dismantling the motor or the machine, and another one supplied to give the proper speed. You will note that this motor is applicable to either the old or the new frames of the Atwood Company. The one shown in the photograph is a very old frame, as you will notice from the gear guard, and the motor is simply installed by cutting out the cross web of the end stand at the lower part. On new machines this cross web is simply omitted in the pattern.

The advantages of this drive are that it eliminates the idlers, bracket, and quarter turn belts necessary to drive from the line shaft to the vertical shaft on the frame. The spindles get an easy start, because they always start with the motor, which must necessarily start from zero, and come gradually up to full speed. Belt slippage is reduced to a minimum. The absence of oil on spindle belts and therefore the slippage on the spindles, is almost entirely absent, because the oiling of the motor is all below the spindle belt, and whatever oil runs down the shaft from oiling the gears flows down the center of the pulley and does not get onto the pulley rim. No safety guards are needed as the spindle belt guards are replaced, no moving parts on the motor exposed.

Figure 59 shows drive for the single deck spinner. The one in the background is a standard vertical motor, two HP., 1760, R. P. M., mounted on the floor and driving direct by motor pulley to the spindle belt. The take-up is driven by the wrap of the spindle belt on the vertical shaft pulley as shown. This is the simplest drive which can be applied, and it takes up about the same floor space as the brackets and idlers used for the belt drive from the line shaft. The one in the foreground is a two HP., 870 R. P. M., motor coupled direct to the vertical shaft which drives the take-up rolls. The motor is mounted in exactly the same way as for the style C spinner and has the same advantages.

PART III—CHAPTER XIII

TRAM THROWING

There are three methods of throwing tram in general use. First, doubling on the Vertical or Jack Pin Doubler as shown by Figure 53 and twisting and reeling in one process known as the Reel Mills. Second, the single process consisting of doubling on the Vertical Doubler, twisting on the regular Second Time Spinner and reeling on the single process reeling frames, of which there are several types on the market as given in a later chapter on Reeling. Third, the 5B Process consisting of doubling and twisting in one process called the 5B, sometimes down spinning and reeling on the single process reel.

The Reel Mills are considered an antiquated process and require the most skilled help to operate as the ends must be tied while the reel fly is running; this must be done so quickly that only the most skilled help can tie a short knot free from waste, besides, on account of the fly not stopping when an end breaks, the skeins are irregular in length. The quality of the tram averages the lowest.

Vertical Doubling

On the single process with the Vertical Doublers, also called Jack Pin Doubling, of any of the various makes now on the market, we must guard against loops, fine threads (that is, singles in two thread, two threads in three, etc.), long knots and waste. Loops may be caused by any of the following conditions that may put a harder tension on one or more threads: Dry jack pins, ends not put together, hard bobbins, soft bobbins, silk wound too wet, waste on jack pins, crossed or looped threads, bobbin head dragging on end of pin, speed too fast causing the bobbin to overrun and throw in loops, silk improperly soaked and fine and wiry threads. Sometimes it takes several of these conditions to make a loopy thread, and at times any one of them may do it, altogether depending on the tension on the thread.

The following are the various speeds and theoretical production per frame of sixty spindle that can be obtained on Columbia Doubler. Line shaft 168 R. P. M.

The best tram and the most efficient speed I find between 170 and 175 roll speed with frictionless large barrel winder bobbins.

These productions can be realized within about eighty-five per cent in actual mill practice.

The 5B process proves to be the ideal process for throwing tram for the following reasons:

Fi.st. As the thread is twisted when it is doubled no ends are apart and this manual defect never appears.

Second. As the spindle is stopped when an end is tied up no hard twist is made at knot. Experienced spinners on regular spinning hold the thread long enough to cause it to twist up from five to ten turns at knot. Learners frequently have fifteen turns at knot. This at 5,000 spindle speed.

COLUMBIAN TRAM DOUBLER
WITH DOUBLER BOBBIN 6.28" AVERAGE CIRCUMFERENCE
LINE SHAFT 168 R.P.M.

Speed	Sizes Cones	Friction Wheel	Spindle Speed	Thread Speed. YARDS PER MIN.
Slow 1	4 to 6	112	298	51
1½	5 to 6	140	373	65
2	5 to 5	168	448	78
2½	6 to 5	201	636	93
3	6 to 4	252	672	117

THEORETICAL PRODUCTION lbs.
60 Spin 10 hrs.
SINGLE THREAD.

Thread Speed	12/14	13/15	300,000	14/16	15/17
51	5.33	5.74	6.12	6.16	6.57
65	6.79	7.32	7.80	7.85	8.38
78	8.15	8.79	9.36	9.42	10.06
93	9.72	10.48	11.16	11.23	11.99
117	12.23	13.18	14.04	14.13	15.09

Third. The breaks on 5B are no more than those had on the Vertical doublers so that all the breaks filling up and waste made in spinning is saved, but it is customary to pay a higher rate and this partly offsets the cost so that in actual practice about two-thirds of spinning cost is saved and about the same per cent of waste.

More wa te is made on 5B's than on Vertical Doubling if care is not taken to keep waste off feed rolls. As the threads need not be put together good and careful hands make less waste on 5B's than on Vertical Doubling. The repair costs and attention required is about equal to the Vertical Doubler and Second Time Spinners combined so that there is no saving in cost of repairs or overseeing.

Speed. The 5B's are operated at from 4,000 to 5,500 spindle speed, the lower speed for No. 1 grade stock, the higher speed for extra or better stock. The following is the production per spindle hour at the different speeds and twists:

5B Traveler and Ring

L. F. Hartson, of the L. M. Hartson Company, gives the following information on the wire or bar travelers and rings on down spinning and the Atwood 5B machines:

"It was on June 1, 1886, that the first down spinners using wire travelers were placed in the mill of A. G. Turner at Willimantic, Ct., by The W. G. & A. R. Morrison Co., of that place. They made the spinner using a 1⅝" traveler and twister using a 2" traveler. Cheney Bros., Belding Bros., Hammond & Knowlton, and Brainerd & Armstrong adopted these frames as well as the Tilt Silk Mill of Pottsville, Pa., about this time. We made the original travelers for these installations. Later the Atwood Machine Co. put out the 5B, similar in construction and type, using the 2 7/16-2 11/16-2 15/16 Ring."

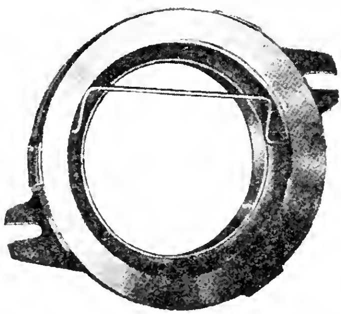


Fig. 60

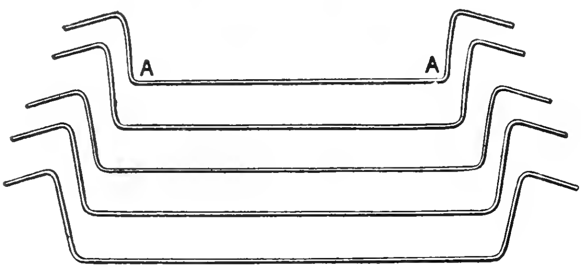


Fig. 61

The Hartson wire or bar travelers are made in lengths as follows: Measuring from points A to A. Figure 61.

1 5/8" for the 2 1/16 Ring
1 3/4" " " 2 7/16 "
2" " " 2 11/16 "
2 1/8 & 2 1/4" for the 2 15/16 Ring.

The number and size in thousandth part of an inch are as follows:

Light	Medium	Heavy	Extra Heavy
No. 7—.018	No. 10—.024	No. 14—.032	No. 19—.042
No. 8—.020	No. 12—.028	No. 16—.036	No. 20—.044
No. 9—.022	No. 13—.030	No. 18—.040	No. 22—.048
			No. 24—.055

Boxed as follows:

No. 7—4000	No. 11 —2000
No. 8—3000	No. 12-14—1500
No. 9—3000	No. 16-19—1000
No. 10—2000	No. 18-24— 500

Example in ordering:

If your ring is 2 7/16 and you want a light traveler, say, "I box 3000 No. 9 x 1¾. Regular leg."

Or with a 2 15/16 Ring and heavy traveler, "I box 1500 No. 14 x 2¼. Short leg."

Usually a short or medium leg is desired on heavy travelers, especially on 2" and longer.

The legs or ends are made in regular, medium and short depending on the tension, size of wire, etc.

The Harry C. Smith Co. numbers are as follows:

No. 3	.0178"
No. 6	.0215"
No. 8	.0243"
No. 10	.027"
No. 12	.0283"

In selecting travelers the spindle speed and thread are the factors to be considered. If the tension is too great, the travelers fly out and a lighter traveler is needed; if too light for the speed of spindles, the traveler also flies out, or it may bend too much and cause the silk to run over the end of head.

On the 2 15/16 ring I find the following sizes give good results on the threads named:

2 Threads	.0178"
3 Threads	.0215"
4 Threads	.0243"
5 Threads	.0270"
6 Threads	.027"
8 Threads	.027 and .0283"
10 Threads	.0283 and .03"
12 Threads	.03 and .032"

On two-thread I find the 2 11/16" ring gives better results than the 2 15/16", and that on some silk better results are obtained with the 1⅝" and the 1¾" than with the regular size 2" intended for this ring.

The fibre head bobbins used on these are No. 37 on 2 7/16, No. 78 on 2 11/16, No. 87 on 2 15/16 ring.

These travelers are cut by the silk in about sixty hours but wear through on the ring in about forty-five hours. There is no harm in letting them run until they wear through and fly off except that the sharp point frequently pricks the shaft and cuts the silk on the bobbin. I have found it advisable to change them weekly.

If the travelers fly out very often then try a lighter and shorter traveler and if that does not remedy it slow down on spindle speed.

On low-grade stock it is impossible to overcome it altogether as the large defects cause an unusual tension which jerks them out of the ring.

Tram Up Spinning

Speed. Tram spinners are run from 4,000 to 7,000 spindle speed. 5,000 to 5,500 is the most efficient speed. The spinning parts range from 135 to 225 spindle, depending on the thread, turn, speed and quality of raw stock. The principal defects to watch for are loops, bad knots and tieing on to a fine thread or single.

Loops are made when ends are not brought together before piecing up. A good spinner knows that an end tied up without getting ends together only runs until it gets to a knot and then breaks down, and therefore carefully avoids this.

Flyers

The drop arm flyers as shown by Figure 42 are generally used except on heavy cords, then the "figure eight" is necessary as shown by Figure 51.

The following table shows the theoretical production at different twists. This production can be reached within about eighty to eighty-five per cent in practical mill experience.

TRAM SPINNERS

THEORETICAL PRODUCTION IN LBS. , 10 HOURS.

SPINDLE SPEED 6000

SINGLE THREAD

On	90 Spindles. TURNS				
DEN.	1	1½	2	2½	3
12/14	26.20	17.46	13.10	10.48	8.73
13/15	28.22	18.81	14.11	11.59	9.40
300,000	30.00	20.00	15.00	12.00	10.00
14/16	30.23	20.15	15.11	12.09	10.07
15/17	32.42	21.61	16.21	12.96	10.80
16/18	34.26	22.84	17.13	13.70	11.42
DEN.	3½	4	4½	5	5½
12/14	7.48	6.55	5.82	5.24	4.76
13/15	8.06	7.04	6.27	5.64	5.13
300,000	8.57	7.50	6.66	6.00	5.45
14/16	8.63	7.55	6.72	6.04	5.49
15/17	9.26	8.10	7.20	6.48	5.89
16/18	9.78	8.56	7.61	6.85	6.23
DEN.	6	6½	7	7½	8
12/14	4.36	4.03	3.74	3.49	3.27
13/15	4.70	4.34	4.03	3.76	3.52
300,000	5.00	4.61	4.28	4.00	3.75
14/16	5.04	4.65	4.32	4.03	3.78
15/17	5.40	4.98	4.63	4.32	4.05
16/18	5/71	5.27	4.89	4.57	4.28

PART III—CHAPTER XIV

HARD TWIST

Wet a thread of crepe and it expands or becomes longer, dry it and it contracts or becomes shorter. This is seen when steaming crepe on large head fibre bobbins; the moisture in the steam causes the thread to swell or expand and forces the fibre head away from the barrel.

The co-efficient of the expansion and contraction does not appear very large, on the other hand the large number of turns wound on each bobbin gives a considerable expansion and contraction. The shrinking on the steaming bobbin is about one-eighth inch which equals about 1,000 yards on a bobbin. The expansion appears from five to ten per cent.

If you stretch a thread of crepe fresh from the spinners it stretches about fifteen per cent and pulls out part of the kink but breaks before all of it is drawn out; wet the thread, which makes it more ductile (wrongly called elastic) and stretch it twenty to twenty-five per cent, then the kinks are drawn out and the twist is set. If you wet it and then dry quickly, keeping a tension on the thread, the kinks are drawn out during contraction.

If it were practical to twist a crepe thread at ninety to ninety-five per cent relative humidity under twenty to twenty-five per cent stretch, the twist could be set whilst twisting, or if run through water and then twisted, the process known as wet twisting in making jute yarns, we would have the same result.

Ductility prevents breaks, reduces costs and waste, and it also permits of increased stretching and shrinking and partly sets the thread, therefore crepe twisted under a humid atmosphere does not kink up as much as one twisted under a dry atmosphere.

Most throwsters use steam to set the crepe twist, which being a hot vapor and very penetrating, causes the thread on the steaming bobbin to become very ductile and when removed from the steaming box the heat quickly drives off the moisture and brings about a quick drying and shrinking. I have found three steamings of nine minutes each with intervals of ten minutes between each steaming gives better results than one steaming of forty minutes. It appears that a greater contraction is obtained by the first method and this sets the twist better.

Care must be taken in steaming to avoid rust spots, as these have a corrosive action on the silk thread and in the course of four or five weeks this eats the thread through or makes it very tender. If the thread is used up soon after being thrown and boiled off before the corrosive action has progressed very far, the boiling-off process neutralizes the action of the rust and the destruction of the thread is stopped.

The following methods are used for twisting crepe:

Doubling on vertical doubler and adding full twist at one spinning using a figure eight flyer. Doubling on vertical doubler and adding only part twist with regular flyer adding balance with one or more twists with flyer. Doubling on vertical doubler, adding one-third twist with regular flyer, medium speed, one-third without flyer at high speed and balance with flyers at medium speed.

Doubling on 5B's, using a short take-up shaft putting in one-third twist with flyer and adding the rest of twist with a flyer.

Doubling on 5B's using a regular No. 78 5B shaft putting in part twist with a disc and adding balance of the twist also with a disc.

Various types of shafts are used for steaming purposes. Iron heads, brass heads, aluminum, fibre, galvanized iron and round blocks or barrels.

Iron heads rust and corrode silk; brass becomes green and makes silk sticky; aluminum is rather expensive; galvanized iron, if not well coated, also causes rust; plain wooden rolls, on account of light weight, have very little contact and there is a tendency to excessive twist and waste; fibre is the best, but warps if shaft is not properly made.

Quilling and Copping. Steaming quills and cops is objectionable as the holes in the quills become smaller and bind on the shuttle spindles, also warp and become rough as the steam raises the grain of the wood. On the cops the paper becomes soft and cops crushed.

Quilling should be done under a humid atmosphere, say seventy to seventy-five per cent relative humidity, so as to make the thread fairly ductile and permit of greater shrinking. After being filled the quills should be placed in a hot, dry box or room, not too hot so as to bake the outside thread and not affect the inside; this will set the thread more fully and prevent the filling shrinking in the cloth on loom and obviates the use of temples. It also draws the oil to the surface and lubricates the thread better.

There are several methods of throwing crepe, each method having its advocate who finds it the best and it is possibly so, with the equipment he has.

The best crepe twist is the thread that shows the greatest uniformity, not the highest average twist, e. g., let us say we are throwing a two-thread crepe with seventy turns per inch. If we put on seventy turn twist gears or pulleys, we cannot hope to average seventy turns, as there are spindles that will run ten per cent slower and under good conditions the twist will average about sixty-six turns. To get an average of seventy turns it is necessary to gear up for seventy-five turns when the twist will range from sixty-five to seventy-five turns.

(Twist tests should be made on not less than twenty inches and care must be taken not to push the twist beyond binding post in straightening out thread.)

With poor spindles, by gearing up for eighty turns it is possible to get a higher average twist than if geared up for seventy-five turns but the range will be considerably greater or from sixty to eighty-five turns and to an inexperienced person who would be governed by the average, it would appear that the twist averaging nearer the twist called for was the best crepe twist, whereas in fact the twist showing the greatest uniformity, even though the average be lower, is the best thread.

Article VI, Throwsters' Rules, Section VIII, reads—The variation of the average twist in turns per inch over or below the average of twist stipulated in contract must not exceed twenty per cent on twist under five turns per inch and ten per cent on twist over five turns per inch.

Twist twenty to twenty-five per cent under twist called for causes a marked difference in shrinking of cloth and therefore twist under fifteen per cent should be carefully avoided. Variation in twist causes uneven shrinkage. The excessive twist does not show so marked an effect in cloth as the slack twist, but it has a tendency to continue shrinking when goods is on the shelf.

Terms Used in Designating Regular and Special Threads

Organzine (commonly called organ), consists of twisting the single thread left fourteen to sixteen turns and then doubling into two or three threads and twisting twelve to fourteen turns right.

2 Thread Organzine is thrown—

- 18 turns first time and 12 turns second time.
- 16 turns first time and 14 turns second time.
- 14 turns first time and 12 turns second time.

3 Thread Organzine is thrown—

- 14 turns first time and 12 turns second time.
- 12 turns first time and 10 turns second time.

Tram. Consists in taking the single thread, untwisted and doubling into two or more thread and twisting right from one to eight turns. The following twist and thread are generally used.

- 2 threads 3 to 3½ turns.
- 3 thread 2½ turns.
- 4 thread 2 turns.
- 5 thread 2 turns.

Over four turns is generally used by the knitting trade.

Chiffon. Consists of a single thread twisted from thirty to ninety turns per inch, left.

Crepe. Consists of two or more thread twisted sixty to eight-five turns, one-half right and one-half left twist.

The following twists are generally used—

- 2 thread 75 to 90 turns.
- 3 thread 60 to 65 turns.
- 4 and 5 thread 55 to 60 turns.

Radium consists of two or more threads twisted in one direction thirty to forty-five turns, left. It differs from crepe in being twisted in but one direction and not twisted as hard.

Voile. Consists of two threads twisted left on the single thread from thirty-five to forty turns, doubled and then twisted right thirty-five to forty turns.

Grenadine. Consists of two threads twisted left on the single thread from fifty to seventy turns, doubled and twisted right from fifty to seventy turns.

Corkscrew. Consists of doubling four threads and twisting twenty-five turns left then doubling up with a single thread untwisting into a five-thread that is then twisted right twenty-five turns, which gives a corkscrew effect.

Fringe. Consists of three thread twisted left fourteen turns, re-doubled into two cord or end and twisted right twelve turns.

Machine Twist. Consists of three or more thread twisted sixteen to twenty turn, redoubled into three cords and given fourteen to eighteen turns right twist.

Embroidery. Consists of twenty or more thread twisted ten turns left, re-doubled into two cord and twisted eight turns right.

PART III—CHAPTER XV

TUSSAH THROWING

Tussah silk reaches the American market principally in three classes: first, the filatures usually reeled from eight cocoons or about thirty-four to thirty-eight deniers; the native re-reel from eighty to 120 deniers; the water reel from 150 to 300 deniers.

The peculiar characteristics of Tussah silk are that it has a strong odor, is from a light to a dark brown color and the thread is very open or lacks cohesion.

The sericin is largely soluble in water and will not stand even a short soaking. The cohesion varies from an open thread to eighty strokes. (China and Japan vary from 150 to 3,500 strokes.)

The skeins usually have gum or reel markings which, even when they are soft, affect the winding if they are not removed. As the thread is very open and consists of eight cocoon fibres, one of these fibres may be gummed down and split off in unwinding, run a band and break down the thread.

Removing of Gum

Tussah filatures are prepared in two ways for winding.

A. The twisted skeins are sprayed or daubed with oil, with a soft camel's hair brush. These skeins are packed in a box tightly for fourteen hours, in which time the oil spreads over the skeins fairly uniformly. The skeins are then untwisted, gum turned out, skeins hung on racks or poles and steamed with dry steam from two to six minutes, depending on the character and hardness of gum. On removing from steam box the gums are pulled apart, not rubbed. The silk is then ready for danders to be skeined on swifts.

Extensive experiments show that Tussah silk needs about six to eight per cent of oil to get the best working results. The sericin contains a small amount of grit, which soon cuts through guide eyes, tension wires and flyers. When the thread is oiled with from six to eight per cent, less breaks are had and the life of guide eyes doubled. The more uniformly this oil is applied the less are the breaks, and logically we have less labor cost and waste.

Any effort made in preparing the Tussah properly for throwing is labor well spent and fully rewarded with better winding and spinning results. The open and split condition of the thread makes necessary a greater care in preparing the skeins for winding than regular Japan silk. If a thread is chafed and a cocoon fibre broken its strength may cause it to run a band or break down the thread.

B. The second plan is to build a steam box with an air automizer to spray on the oil when skeins are being steamed. The skein should be hung on a hoop with wide hooks and this hoop revolved while the oil is being sprayed on the silk.

A steam automizer may be used when air is not available, but care must be taken to use dry steam. Twenty-five per cent better results can be obtained by this method than with plan A.

Winding

A thread speed of about 165 yards per minute is the most efficient. The breaks vary from 80 to 600 on 300,000 yards. At times it is possible to reduce the breaks from 300 to 400 per 300,000 yards by careful treatment before winding.

Doubling and Spinning

The open condition of the thread will not permit fast speeds. Quick traverse and large barrel bobbins should be used in all departments so that the threads do not lie so close together. This facilitates the finding of an end and prevents unnecessary waste.

Down spinning, or the 5B's combining the doubling and spinning in one process at from 2,000 to 3,000 spindle speed gives the best results. Some trouble is experienced with the cocoon fibres splitting off and running around the feed rolls but this may be minimized by reducing the clearance between rolls and feed roll holder so that no more than two or three layers can wrap on, also by milling a groove across the roll to facilitate cutting off the waste.

Up spinning is not suitable for Tussah excepting after a slight tram twist has been added.

PART III—CHAPTER XVI

REELING

Thrown silk skeins were originally reeled 1,000 yards without any crossing and the skeins banded off same as we now do sizing skeins. I. M. Grant, of Cheney Bros., invented the Grant Reel with its traverse and cross skeins, which is now universally used.

There are two styles of crossing in general use, one called the open or large, and the other the close or small diamond. The open diamond is made with a twenty-four tooth gear on vertical shaft and ten tooth gear on reel-fly. This gives twenty-one complete crossings across and back in fifty revolutions of the fly. The skein shows six crosses. The diamond is eight inches long and 13/16 inch wide. This gives four inches of thread between the crosses. This diamond can also be made with a 36 x 15 gear combination and as they mesh better fewer bad crossings are made than with the 24 x 10 combination. This diamond gives the best winding results on heavy threads but causes poor winding when used on two thread organzine.

The close or small diamond is made with a 24 x 11 tooth combination gearing and gives twenty-three complete crossings across the skein and back in fifty revolutions of the skein. It shows ten crosses. The diamond is three and a half inches long and three-eighths of an inch wide with but one and three-fourths inches of thread between the crosses.

The latest types of reels on the market are shown by Figures 62, 63, 64.

The 7K type embodies a very desirable feature with the bobbin board raised high enough to prevent over-stooping in piecing up, to which the reelers object.

Speed. The flys are run at from 425 to 475 R.P.M. At 425 R.P.M. the following numbers of reels can be reeled in ten hours, on four flys, allowing two and a half minutes tie off;—two thread Organzine.

Yards	No. Reels
20,000	40
15,000	48
10,000	60

When reelers do their own lacing, the following reels can be produced on 20 M yards of two thread Organzine:

Two Flys	18 Reels
Three Flys	24 Reels
Four Flys	28 Reels
Five Flys	33 Reels
Six Flys	36 Reels

The standard circumference of thrown silk skeins are 44". The following are the lengths generally used:

Two Thread Organzine	—15,000 to 20,000 yards.
Three Thread Organzine	—10,000 yards.
Two Thread Tram	—10,000, 15,000, 20,000 yards.
Three Thread Tram	—10,000 yards.
Four Thread Tram	— 7,500 and 5,000 yards.

Article V of Throwsters Rules. Reeling into skeins. An average variation of five per cent shall be allowed from the number of yards per skein as ordered for thrown silk. The minimum number of test skeins is twenty.

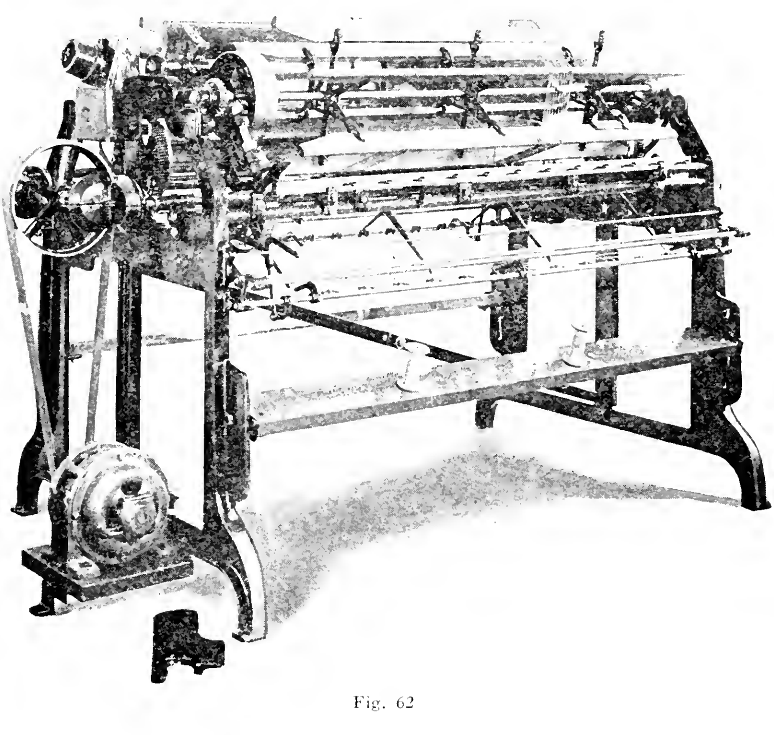


Fig. 62

Lacing

Lacing is done with bare fingers and also with the assistance of combs and needles as shown by Figs. 65-66 and 67. On the close diamond a lacer cannot maintain a high speed all day long without the use of comb and needles as their

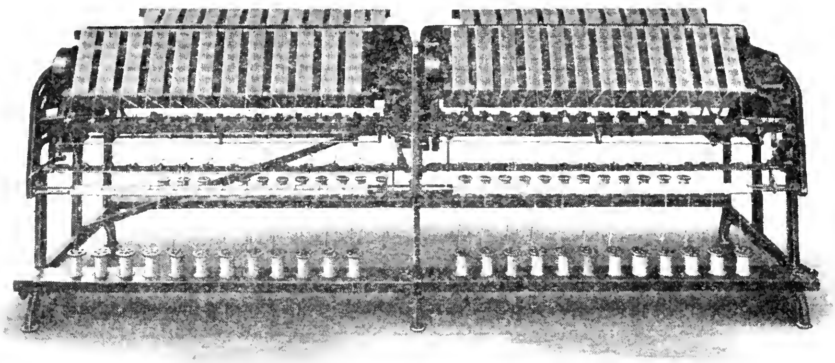


Fig. 63

fingers get sore. It requires more time to become skilled with comb and needle but a higher efficiency can be maintained when a lacer once becomes expert. At the best it is a very tiresome job and the turnover of help is very great in that department. It has been found more efficient to let each reeler reel his or her own flys and while this requires more reeling frames, it has been found to be worth the difference in first cost.

When lacing is done by separate lacers, then the flys are placed in horses as per figure 68. Skeins are laced three and four times as may be ordered.

Soft twisted lacing cords should only be used as hard twisted cord is liable to kink up in dyeing and entangle in silk threads and cause many breaks.

Bundling

The skeins when stripped off reels are rolled up in hanks of twelve skeins each. These are weighed up in sets of four and light and heavy reels taken out and redrawn and re-reeled.

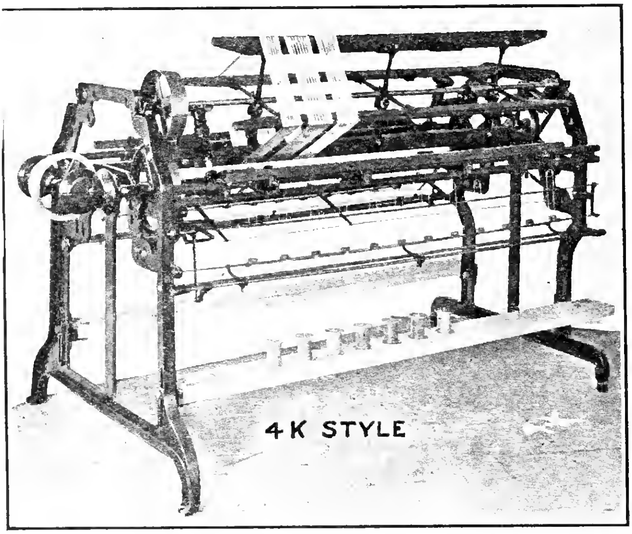


Fig. 64

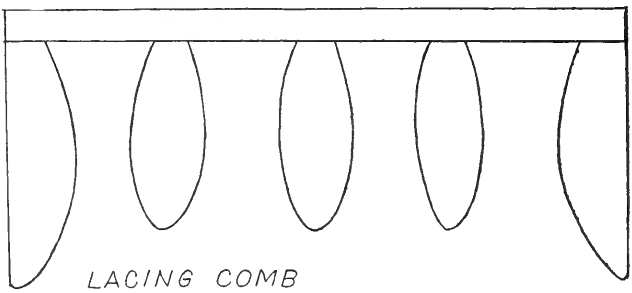


Fig. 65

The bundlers should carefully inspect the skeins, tie off cross threads, correct defective lacings, tie off defective work and send it to redraw departments for winding out, then for correction in other departments. Two thread Organzine is usually bundled eighty rolls, 160 skeins to bundle. Three thread Tram, seventy rolls, 210 skeins.

The bundles after having the required number of rolls and skeins are pressed in shape mostly with a hand press. Figure 69 shows one of the latest hydraulic presses on the market for which great claims are made by the maker, the Scranton Silk Machine Co.. Where girls are used as bundlers either power or hydraulic presses should be used.

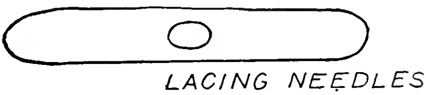


Fig. 66

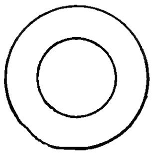


Fig. 67

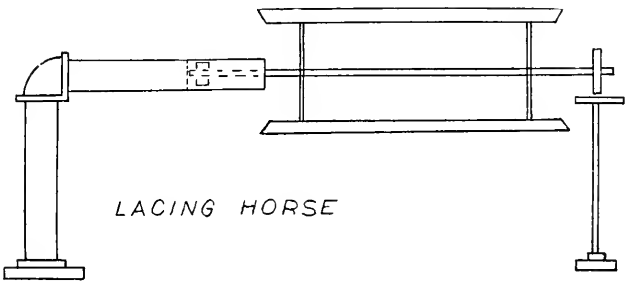
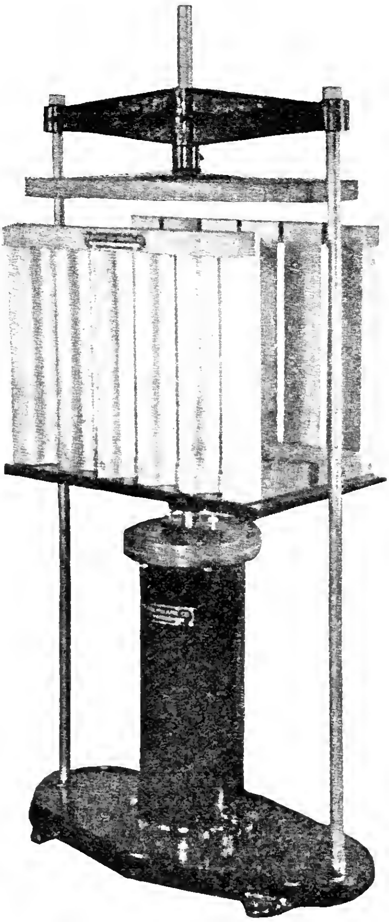


Fig. 68



BUNDLING PRESS

Fig. 69

PART III—CHAPTER XVII

THROWSTERS' REPORTS

There is a great variance in reports made by different throwsters on the working qualities, evenness and cleanness of the same silk. There appears to be an impression amongst some throwsters that an adverse report questions their ability to judge silk or handle it properly and that it may lead to disputes with raw silk brokers; there is a tendency then to make the report represent what the grade of silk calls for instead of its actual working qualities. More often the matter is left to the forepeople, who, in making an inspection for cleanness and evenness, simply hunt until they find something and then stop; the very fact that the best of silk has defects of all kinds and that it is the relative number in the silk that indicates whether the silk is clean or unclean is not realized by the average mill foreman.

There is a great difference in silk of the same chop, one lot being clean and even and spinning very well, while the next lot of the same chop may run just the opposite. Throwsters as a rule are not in a position to grade silk and should not be expected to do so; they can only be asked to report what they find, and this report should be made by a uniform method so that a manufacturer having silk thrown by different throwsters may know definitely that the report represents actual conditions of the lot and is not to be governed by a difference in judgment at the different mills.

There are throwsters who report the working qualities of each department, but on account of the combination process this is no longer possible: a very thorough investigation of the subject covering many years on single and combination process shows that the first spinning process on organ gives a truer report on the working qualities than any other department in the mill, and as this process is to be found in both single and combination processes it makes possible a uniform report, not only on the working qualities, but also on the evenness and cleanness. Mr. Rosenzweig's several articles in the Silk Journal and my address before the first Silk Convention at Paterson show that it is the extremes in silk that cause the trouble in throwing and weaving, and while many of the defects in raw silk go through the first spinning without breaking down, the relative number I found true to the general evenness or cleanness of the silk, so that whilst an absolutely true report is not gained it will be found to answer the

purpose fully for what can be expected from a throwster report. My recommendations are that on organ the report cover the Strength, Color, Evenness, Cleanness, Winding break test or Count, and a Break test or Count on first spinning either single or combination process. On tram the same as organ, except that the breaks be made on doubling, on the single bobbin, either the ordinary Jack pin or 5B. That all of them be based on 300,000 yards single thread; that the Evenness and Cleanness be taken from the First spinning break test and be conducted as follows:

First make a break test on First spinning using blank form 70; use a regular spinning part and run it from one to three hours, the longer the better; in no case make test on less than 300,000 yards or about a pound of 14/16 denier silk. At 12,500 spindle speed sixteen turns per inch, it takes 230 spindles one hour to spin 300,000 yards.

Yds. per hr. =

$$\frac{12{,}500 \text{ (spindle speed)} \times 60 \text{ (min. per hr.)}}{16 \text{ (turn per inch)} \quad 36 \text{ (in. per yd.)}} = 1302$$

$$\text{To produce 300,000 yards} = \frac{300{,}000}{1{,}302} = 230 \text{ hrs. 1 spindle or 230 spindles 1 hr.}$$

Hence the breaks per spindle hour × 230 = the breaks per 300,000 yards at 16 turn, which we will call × breaks.

For other speed and turn see table following.

The following tables show the spinning qualities classified for evenness:

Spinning breaks due to fine ends.

Class.	Breaks Per × Yards on 300,000 Yards.
Very Good	4 and under
Good	5/6
Fair	7/8
Only Fair	9/10
Poor	11/12
Very Poor	Over 12

Form 70

First Time Spinning Test.

Cleanness classified by breaks due to all defects except fine ends.

Class.	Breaks Per x Yards.
Very Good	8 and under
Good	9/12
Fair	13/16
Only Fair	17/19
Poor	20/24
Very Poor	Over 25

Tram Doubling Test.

Evenness classified by breaks due to fine ends.

Class.	Breaks Per x Yards.
Very Good	5 and under
Good	6/7
Fair	8/9
Only Fair	10/11
Poor	12/13
Very Poor	Over 13

BREAK TEST

FIRST TIME SPINNING

Date January 1918

Lot No. Sample Stock Japan

Time test started 2 PM Stopped 5 PM

Turns 16 Spindle speed 12000

Remarks NO SPINDLES 360

Rule = 240

Evenness	Actual Breaks	Breaks 300000 yards.
Fine	50	12
Cleanness		
Waste	30	
Bad knots	20	
2 threads	5	
Slugs	20	
Loops	15	
Split ends	10	
Unknown	15	
Total	165	37

360 × 3 =, $\frac{50}{1080}$ = .0463 × 240 = 11.11 Call 12

360 × 3 = $\frac{165}{1080}$ = .153 × 240 = 36.7 Call 37

Tram Doubling Test.

Cleanness classified by breaks due to defects other than fine ends.

Class.	Breaks Per x Yards.
Very Good	5 and under
Good	6/7
Fair	8/9
Only Fair	10/11
Poor	12/13
Very Poor	Over 13

On Columbian Doubler use the following rule to determine the breaks per 300,000 yards:

With Doubler bobbins having head 2½" diameter, barrel 1½", average circumference 6.283"—Friction Roll 168 R. P. M. 78 thread yards per minute, multi-

ply breaks per single hour single thread by 64. Friction roll 140 R. P. M. multiply breaks per single hour single thread by 77.

Rule and formula to calculate breaks per 300,000 or X yds.:—One turn per inch, 1.000 spindle speed in one hour produces 1,667 yards.

To produce 300,000 yds, will take as many hours as 1,667 is contained in 300,000 or 180. Therefore, 180 times breaks per spindle hour—breaks per 300,000 yards.

Formula:

300,000 = yards per X pounds
1,667 = yards spun in 1 hour on 1 turn on 1,000 spindle speed
Sp. = Spindle speed
T. = Turns
YT. = Yards to turns at 1,000 spindle speed
YTS. = Yards to turns at respective spindle speed
X. = Rule X breaks spindle hr. for breaks 300,000 yards

$$\frac{1{,}667}{T} = YT. \times Sp. = \frac{300{,}000}{YTS} = X$$

Example:— $\frac{1667}{10} = 1.66.7 \times 6{,}000 = \frac{1{,}000{,}300{,}000}{1{,}000} = 300.$

Table Per X Yards.

Multiple table by breaks per spindle hour gives breaks per 300,000 or X yards.

Turns	1	1½	2	2½	3	3½	4	4½	5	5½
Speed 3500	51	77	103	128	154	180	205	231	257	282
4500	40	60	80	100	119	140	160	180	200	220
5100	35	53	71	88	106	123	141	159	177	196
6000	30	45	60	75	90	105	120	135	150	165
7000	26	39	51	64	77	90	103	116	128	141
Turns	6	6½	7	7½	8	8½	9	9½	10	
3500	308	334	359	385	411	437	463	488	514	
4500	240	260	280	300	320	340	360	380	400	
5100	211	229	247	264	282	300	318	335	352	
6000	179	195	210	225	240	256	271	285	300	
7000	154	167	180	192	205	218	231	245	257	

Table of Multiples, which multiplied by the breaks per spindle hour gives breaks per 300,000 or X yards.

Turns	10	11	12	13	14	15	16	17	18	19	20
Speed 6000	300	330	360	390	420	450	480	510	540	570	600
6500	277	304	331	360	388	415	442	470	498	526	553
7000	257	282	308	335	360	385	411	437	463	488	514
7500	240	264	288	312	336	360	384	408	432	456	480
8000	225	247	270	292	315	337	360	382	405	428	450
8500	212	233	254	275	296	317	339	360	381	402	423
9000	200	220	240	260	280	300	320	340	360	380	400
9500	189	208	227	246	265	284	303	322	341	360	397
10000	180	198	215	234	252	270	288	306	324	342	360
10500	171	188	205	223	240	257	274	291	309	326	343
11000	163	180	196	212	229	245	261	277	294	311	327
11500	156	172	189	203	219	234	250	266	281	297	312
12000	150	165	180	195	210	225	240	254	270	285	300
12500	144	158	172	187	201	216	230	245	259	273	288
13000	138	152	166	180	194	208	222	236	249	263	276
13500	133	146	159	173	186	200	213	227	240	254	266
14000	128	141	154	167	180	193	205	217	230	243	257
14500	124	136	149	161	173	186	198	211	223	235	247
15000	120	132	144	156	168	179	191	204	216	229	240

On 5B use spindle speed and turns as per table; e. g. take the test shown on sample blank, we find the test three hours at 12,000 spindle speed at sixteen turns. Multiplying the hours by the number of spindles we have the time of one spindle in hours; this divided into the total breaks due to fine ends give the breaks for one spindle one hour and on 300,000 yards would equal 240. See table for sixteen turns 12,000 speed or twelve breaks per X yards; the other defects = 25 per X yards; this according to table would show the Evenness as very poor, and the Cleanness, poor.

Raw silk defects come very irregular; the less the number the more irregular, the greater the number the more regular. Therefore, one of the first things to be considered in testing is the minimum amount of silk that must be tested or inspected to give true results.

I have found that 60,000 yards is the minimum amount that holds true to working results. A full bobbin two inches diameter exposes about twenty-five yards to view; to examine 60,000 yards would take 60,000 = 2,400 bobbins. This shows that to inspect the bobbins is not practical. I admit that the average intelligence of spinners is such that they cannot all be trusted to make break tests, but I have found that with illustrations showing the different defects there can always be found a few hands who will do the work properly, and even though

they do misname a few it means no error in the final result. Where the department is small the foreman will probably prefer to run the test himself.

Strength. One of the essential qualities of an organ is strength, which is to be classified according to the tenacity table given in Chapter VI. A throwster can hardly be expected to make tenacity tests for the benefit of his patron, although some of the advanced throwsters do it as an accommodation. This is not altogether necessary to get true strength report, although a few tests must be made to get the various classifications correct. When flyers are used on second spinning, this department shows weakness in the thread by the excessive breaks, and it also may be observed in the first spinning process by careful observations and comparisons. Of course fine ends must not be taken as weakness.

A convenient form of Reports is given by Form No. 71.

STANDARD THROWSTERS REPORT

JOHN DOE & COMPANY

Date Jan 1918

To John Doe & Company
New York

Lot No. Sample Mark and Bale No. Sample

Stock Japan Chop Sample

COLOR	UNIFORMITY OF COLOR	SKEIN
White X	Even X	Amer. St. X
Ivory	Slightly uneven	Not ST.
Cream	Very uneven	

GUMS, hard ___ Soft X Narrow ___ Free ___

STRENGTH	EVENNESS	CLEANNESS
Very good	Very good	Very good
Good X	Good	Good
Fair	Fair	Fair
Only fair	Only fair	Only fair
Poor	Poor	Poor X
Very poor	Very poor X	Very poor

WORKING QUALITIES

Winding count 30 First spinning count 37

REMARKS: (Note here which defects predominate when evenness and cleanness are under good.)

Waste, Bad knots and slugs are excessive

JOHN DOE & COMPANY

PART III—CHAPTER XVIII

THROWSTERS' CLEARANCES

There are five conditions affecting throwster clearances. First. The gain of weight in soaking. The conditions affecting the absorption or amount of emulsion retained by the raw silk in soaking are:

A. The acidity and nature of silks, the acidity of oil and soap.

B. The volume of soaking solution, or the amount of water used.

C. The per cent of sericin or gum.

D. The length of time soaked.

E. The openness of skeins and method of putting silk in tub.

F. The size of silk about one-third of one per cent increase to every denier finer than fourteen.

G. Temperature of soaking bath: maximum take-up at eighty-five degrees F.; seventy-five degrees F. shows seven per cent less; ninety-five degrees F. shows ten per cent less. Hard nature Japan and China excepted.

H. The hardness of water.

I. The time and speed of whizzing.

Second. Moisture in mill.

Third. Friction losses in mill, from one to three per cent., depending on the nature of emulsion, method of throwing and evenness of soaking.

Fourth. The amount of waste made in throwing.

Fifth. Mixtures of silk.

Sixth. The integrity of mill superintendents.

The nine conditions affecting absorption in soaking show the need of uniform and careful methods in the soaking process. The common practice of guessing at the amount of soap, oil, borax and water instead of carefully measuring same, feeling for the temperature instead of using a good thermometer, using hard water, particularly when of a changeable quality, instead of softening same, soaking skeins unopened, allowing the emulsion to stand and putting in silk before first stirring same, are responsible for many mysterious boil-off certificates from the conditioning house and private boil-off tests, which the throwster can possibly trace to one or more of the haphazard methods named.

Under absorption, chapter eight on Soaking, a variation of from two to twenty per cent is shown on an oil soaking in the same tub which was reduced to a

variation of but four per cent when the emulsion was sprayed on the silk. On an emulsion of one per cent soap and four per cent oil the variation was reduced from six per cent with the immersion method to one per cent. with the spraying method.

Friction losses. The more uneven the absorption, the greater are the friction losses, as the outside of the skein having a heavy coating of oil and soap loses a larger per cent than that having only a slight absorption. A considerable amount is lost in handling the skeins in winding room.

Doubling with plush tension also robs the thread of more oil than the porcelain and wire tension.

Moisture. It is a common occurrence in spring to have the reels increase in weight four per cent over night when warm weather sets in with its humid atmosphere and heat is kept off mill day and night, and the reels lose a like amount in fall when changing from warm humid weather to dry windy and cool weather with heat on mill day and night. Mills having no humidifying system, which clear with a gain of from one to two per cent in summer time will show on the same soaking absorption a loss of from one to two per cent during the fall and winter months. This dry condition causes the silk to become brittle.

To overcome this and make the silk ductile, or pliable, it is customary in mills having no humidifying system to soak more heavily during the fall and winter months. This practice has been frequently misjudged as being done to cover up excessive waste. Those having humidifying systems can save this extra soaking, but they must be on guard to avoid excessive gains due to moisture settling out on silk when rooms idle at night are permitted to get too cool.

Waste. The waste made in throwing two thread organzine is in proportion to the breaks; on tram in proportion to the breaks and thread.

On two thread organzine, single process, the following rule serves as a basis for waste with experienced help: Winding count times 1½; first spinners breaks per 300,000 yards times 1½. Doubling breaks per 300,000 yards, single thread, times 7. Second time breaks per 300,000 yards two thread, times 2. Reeling 00.10%; floor and bobbin, all department, 00.15%; unknown, that carried out or destroyed, 00.15%. Silk lost in boiling off raw silk 00.10%. The following table was compiled by these rules:

Two Thread Organzine

Class silks running very well.

Winding count 22 to 32, waste	00.33%	to	00.48%
First spinning breaks 16, waste	00.24%	—	00.24%
Organ doublers breaks 4 single thread, waste	00.26%	—	00.26%
Second spinning breaks 13, double thread waste	00.26%	—	00.26%
Reelers average	00.10%	—	00.10%
Floor and bobbin average	00.15%	—	00.15%
Unknown average	00.10%	—	00.10%
Lost in conditioning raw silk	00.10%	—	00.10%
Total	1.56%	—	1.71%

Two Thread Organzine

Class silks running well:

Winding count 32 to 46, waste	00.48% to	00.69%
First spinning breaks 17 to 21, waste	00.25% "	00.32%
Organ doubler breaks 5 to 6, waste	00.35% "	00.42%
Second spinning 14 to 20, waste	00.28% "	00.40%
Reelers	00.10% "	00.10%
Floor and bobbin	00.15%	00.15%
Unknown	00.10%	00.10%
Loss in conditioning raw silk	00.10%	00.10%
Total	1.81%	2.28%

Two Thread Organzine

Class, silks running fair:

Winding count 47 to 62, waste	00.70% to	00.93%
First spinning breaks 22 to 26, waste	00.33% "	00.49%
Organ doubling breaks, 7 to 8, waste	00.49% "	00.55%
Second spinning breaks, 21 to 24, waste	00.42% "	00.48%
Reelers average waste	00.20% "	00.20%
Floor and bobbin average waste	00.30% "	00.30%
Unknown average waste	00.10% "	00.10%
Loss in conditioning raw silk waste	00.10% "	00.10%
Total	2.64%	3,15%

Two Thread Organzine

Class, Silk running poor:

Winding count 62 to 82, waste	00.93% to	01.23%
First spinning breaks 26 to 39, waste	00.39% "	00.58%
Organ doubling breaks, 10 to 20 waste	00.70% "	01.40%
Second spinning breaks 24 to 37, waste	00.48% "	00.74%
Reelers average	00.20% "	00.20%
Floor and bobbin average	00.30%	00.30%
Unknown average	00.10%	00.10%
Loss in conditioning raw silk waste	00.10%	00.10%
Total	3.20%	4.65%

Several years of close investigation show that each department cleans and perfects the thread to a certain extent; silk spinning poor, generally doubles a class better or fair; on second spinning runs still better or "well." This shows that a relation exists between the amount of waste made in throwing an organzine and the first time spinning breaks, and that from the sum of the winding and first spinning breaks the amount of waste and throwing costs can be closely estimated.

On 5C spinning the waste is about the same as single process spinning, as on every end tied up there are always two threads.

Table of Waste Made in Throwing Trams

2	Thread	Class	Very	Well	1.34%	Poor	3.27%
3	"	"	"	"	1.50%	"	3.65%
4	"	"	"	"	1.60%	"	3.52%
5	"	"	"	"	1.73%	"	3.63%
6	"	"	"	"	1.76%	"	3.71%
7	"	"	"	"	1.80%	"	3.80%
8	"	"	"	"	1.83%	"	3.89%

Mixture

Can a throwster prevent mixtures? No, not as long as boys and girls make mistakes. Does it follow then that a throwster cannot return to the owner the proper amount of silk, less the actual waste made, and that the owner must take chances on his return? Not necessarily, so, as all throwsters have checking and follow-up systems by which they do check and correct mixture by separating out the mixture and returning same to respective lots.

In view of the numerous conditions affecting throwsters' clearances, how can a throwster know when he is returning to the owner the proper amount of silk, less the actual waste made? This is one of the perplexing problems of the commission throwster. First, there is the variance in the raw silk as to its nature, and working qualities of the same chop. I have thrown extras of the same chop, that on account of the change in its nature showed a variation in take-up of from forty to sixty per cent of the anhydrous solution used or showed a soaking gain of 2.75 per cent on lot one and 4 per cent on lot two; the waste was 1.75 per cent on the first lot and 2.25 per cent on the second.

The clearance on these lots showed the following:

Lot 1

Invoice weight	100.00 lbs.	
Soaking gain lot	2.75 "	
	102.75 lbs.	
Actual waste		1.75 lbs.
Returned (1% gain)		101.00 "
	102.75 lbs.	102.75 lbs.

Lot 2

Invoice weight	100.00 lbs.	
Soaking gain	4.00 "	
	104.00 lbs.	
Actual waste		3.25 lbs.
Returned (00.75% gain)		100.75 "
	104.00 lbs.	104.00 lbs.

The throwster reported lot 2 as running poorly but returned practically the same amount of silk; this put a discredit on the throwster's report and aroused suspicion that he reported it running bad, to cover an abnormal waste, and soaked it heavier to hide the actual amount made. The facts, however, of the case are, as already shown, that lot 2 actually gained more in soaking and that the throwster was innocent of any bad practice.

Case two. A manufacturer bought one hundred bales of chop A, which he sent to his throwster in ten bale lots. Eight of these lots were practically alike and cleared with an average gain of one per cent. The eight lots ran well, the average waste made was two per cent.; the soaking gain average three per cent. We have then the following clearance.

Invoice weight	100.00 lbs.	
Soaking gain	3.00 "	
	103.00 lbs.	
Waste		2.00 lbs.
Returned weight (gain 1%)		101.00 "
	103.00 lbs.	103.00 lbs.

The ninth lot was of a hard nature and the soaking gain was only 1.80 per cent ; the lot had a great many fine ends and the actual waste made was three per cent. In addition to this while the lot was reeling the weather changed from humid summer conditions to dry windy cool weather, heat was kept on mill day and night and the silk dried out two per cent. The clearance showed:

Invoice weight	100.00 lbs.	
Soaking gain	1.80 "	
	101.80 lbs.	
Waste		3.00 lbs.
Dried out		2.00 "
Returned (Loss 3.20%)		96.80 "
	101.80 lbs.	101.80 lbs.

It will be observed that the eight ten bale lots cleared with a gain of one per cent, while the ninth lot with a loss of 3.20 per cent or a difference of 4.20 per cent. To convince a customer that the throwster had made but one per cent more waste would be a very difficult task without a combination conditioning and boil-off test. I might present a great many other conditions that frequently get together on a lot and cause a bad clearance which questions the integrity and ability of the throwster, of which he is entirely innocent. I presented these clearances to show that returns may vary as much as four per cent and yet not show any excessive waste, and that conditioning house returns showing a great variance between the actual waste made and the silk returned are within the possibilities of actual mill happenings. Before judging the throwster, one should

carefully inquire into the condition already named, also learn whether his mill is humidified or only partly humidified. Does he soak heavier in winter to make his thread more pliable and overcome the greater friction losses, thus serving the interests of his customer by decreasing the breaks and making less waste?

I have no desire to shield the disreputable throwster who robs the customer sending high grade stock to make up the losses of those sending low grade silk, nor have I any sympathy for the customer who demands a uniform clearance the year round and forces the weak-kneed throwster to accumulate a surplus stock in summer to make up his winter losses; but I do want the trade to appreciate that the numerous conditions affecting clearance will at times give very mysterious returns which may not show any excessive waste, and that the integrity of the men who have to deal with the clearance of the lots, is the vital question in selecting a throwster. I refute the statement that the throwsters are a bunch of crooks and challenge any business to show a higher percentage of honorable men. Don't forget that one of the foremost advocates of conditioning this country has ever had was a throwster (I refer to the late Henry D. Klots), and that many of the leading throwsters today prefer to operate on the one hundred per cent basis so as to avoid all disputes and annoyances.

I do not mean to condemn the practice of selling thrown silk on a specified boil-off, but desire to take this opportunity to show the necessity of it. The reason for heavy returns on hosiery trams and crepes is given in my article on special soaking. As to organzine, I desire to say that by referring to the conditioning house report you will observe that Japan raws boil off from sixteen to twenty-two per cent, an average of about eighteen per cent. A merchant selling thrown silks takes the risk of market advances, irregularities of chops, waste, raw boil-offs, unknown waste, labor troubles, etc. He must soak heavily enough so that his returns will show a safe average. Take the lots showing a raw boil-off of twenty-two per cent on which if he sells on a twenty-three per cent boil-off, he has but one per cent margin which will not cover his waste. A higher boil-off is not always intentional but frequently due to a greater absorption on the lot because of its peculiar nature and other conditions already named. We must keep constantly in mind that we can draw our conclusions only on averages and not on any one specific instance.

Is it possible to clear by the skein? No, as a 13/15 denier silk may vary from one to ten per cent in yardage to the pound; then, too, different processes in throwing stretch the thread differently.

Is there any known method that is absolutely true and by which a manufacturer may know how much waste his throwster has made and when he is receiving the silk actually due him? There is no absolutely true method, but the combination conditioning and boiling-off test, as made by the United States Testing Company, is true within one-half of one per cent, and this may be in favor of or against the throwster, depending on how he soaked his silk.

Boil-off tests are made twice on the same silk in which the soap is twenty-five per cent of the absolute dry weight. When a throwster uses an emulsion of ten per cent of soap and two per cent of oil, he gives the thread a slight stripping in soaking and when the boil-off test is made the boiling off is more thorough than where the emulsion is made up of equal parts of soap and oil or the proportion of one soap to four oil. In other words, when a throwster uses an emulsion in which the oil does not neutralize the action of the soap on the silk gum or strips off part of the gum, he gets the equivalent of adding that much more soap to the silk boiled off for him and for which he had no one else to blame. It must be remembered that all silk tests are not absolutely accurate and we must confine ourselves within certain limits and because of this the waste allowances must not be too low. I have found two and a half per cent a fair amount. Several years of observations and tests convince me that the conditioning house methods are reliable and the waste shown by their clearances closely follows that actually made in throwing.

I desire to condemn strongly the practice of selecting a few skeins for boil-off test and estimating the throwster waste by the result obtained. The facts given in this article should prove conclusively that this is a very unfair method and may be very misleading.

Is it profitable to the owner to pay three and a half cents per pound for combination conditioning and boiling-off test? My advice to the manufacturers is do it, at least occasionally; it helps the throwster to a higher efficiency.

To the throwster I would say, watch your soap, observe the methods named for proper soaking, watch your waste carefully, and you will find the combination method very satisfactory to work under.

The One Hundred Per Cent Throwing Method

By D. E. Douty of the U. S. Testing Co.

The following is the "One Hundred Per Cent Throwing Method:"

It is the opinion of many of the best informed men in the silk trade that the entire industry would greatly benefit if all throwing transactions were conducted on the basis which is herein explained.

The One Hundred Per Cent throwing method, closely corresponding to what is known in Europe as La Grande Facon (equivalent to "the complete working out" or demonstration) is a method of adjusting the price to be paid for throwing, on a basis which determines the amount of waste made by the throwster for which he is required to pay at the thrown silk price. This method of fixing throwing prices, which ascertains the amount of silk returned, and thus decides the real cost of the thrown silk, has been followed in Europe for many years. Experience has conclusively proved its value.

Factors to be Considered. The waste made in throwing varies with the character of the silk in each lot, and as market values constantly fluctuate, it follows that throwing prices may vary from time to time. The waste to be figured

on each lot is, therefore, also a matter for consideration. Silks of good quality, on account of the smaller waste made, regardless of their better working, should cost less for throwing than inferior silks.

The throwster's price must be sufficiently high to cover the value of the waste expected in throwing.

In settling the price to be paid for the waste, the owner and the throwster must agree on a fair value for the raw silk.

Determination of Waste. To determine the exact amount of waste made, four facts are necessary: the conditioned weight of the raw silk, the conditioned weight of the thrown silk, the per cent of boil-off of the raw silk, and the per cent of boil-off of the thrown silk; therefore, the silk, both before and after throwing, should be tested at the Conditioning House. The throwster's charge is based on the conditioned weight of the raw silk.

Comparative Illustrations

The following illustrations are presented to show the difference in the methods of figuring the throwing charges by the Old Method, by the One Hundred Per Cent method, and by La Grande Facon adjustment.

Modifications of the raw silk prices due to the terms of sale, have been purposely omitted, though these may be figured if desired.

The figures used in the examples for prices and per cents of waste are not to be taken as an indication of the customs prevailing in the trade, but are selected for the purposes of demonstration only.

Throwster's Bill Under Old Method

(Example A.)

Basis:—

Japan raw silk, for organzine, invoice weight 102.22 pounds.

The invoice weight is assumed to be conditioned weight plus 2 per cent.*

Price, $4.00 per pound conditioned weight, equal to $3.92156 per pound invoice weight.

Price for throwing, 65 cents a pound on invoice weight. The throwster's bill will therefore be:

102.22 pounds at 65 cents, equals....	$66.44
Deduct raw boil-off sample	
.22 pound at 65 cents, equals..	.14
	$66.30

This reduction of the raw boil-off sample is made to bring example A to the same basis as the succeeding examples in which the raw boil-off sample is not sent to the throwster.

*On the New York market, raw silks are sold actual weight, or invoice weight, or conditioned weight. Japan silks, China steam filatures, and Canton filatures, are also sold conditioned weight plus 2 per cent and China re-reels and Canton re-reels plus 2½ per cent.

Under the rules and regulations to govern transactions in the silk trade of the United States, approved by the Silk Association of America, as amended August 9, 1911, all silks may now be sold conditioned weight without any per cent of regain over the usual 11 per cent added to the absolute dry weight.

One Hundred Per Cent Method Calculation for Waste

It will be observed that, under the Old Method, no mention whatever is made of the amount of waste expected to be made in throwing, the custom being that the owner of the silk takes this risk.

Under the One Hundred Per Cent method, the throwster accepts the risk, and guarantees the return of the silk received, or its equivalent value, basing the throwing price on the per cent of waste expected in throwing (in this case taken at 2½ per cent). The method for determining the amount of waste follows:

Subtract raw silk price, conditioned weight..$4.00

Throwing price ....$0.7825 per pound

Making the cost in this instance by One Hundred Per Cent method, on the conditioned weight basis, a sum of $0.1325 in excess of the former price of 65 cents on the invoice weight.

Formula for Calculating One Hundred Per Cent Throwing Price

To the raw silk price, conditioned weight, add
The throwing price, conditioned weight,
Divide this sum by 1.00 less expected per cent of waste,
From this, subtract the raw silk price conditioned weight,
Result is throwing price One Hundred Per Cent method.

Throwster's Bill on One Hundred Per Cent Method

The throwster now makes his charges as follows:

(Example B.)

100 pounds at $0.7825 equals....................		$78.25
Less 2½ pounds waste at $4.00 for silk equals......	$10.00	
Less 2½ pounds at $0.7825 for throwing equals....	1.95	
2½ pounds at $4.7825 for the thrown silk equals..		11.95
Making total charges by throwster.............		$66.30

This is exactly the same charge as shown in Example A after the weight of the sample has been deducted.

Thus at an agreed price of $4.00 for raw silk, with the throwing price by the Old Method at 65 cents, allowing 2½ per cent for waste, the equivalent price for throwing on the One Hundred Per Cent basis is practically 78 cents.

Advantages of the One Hundred Per Cent Method

1. The cost per pound of the thrown silk is known definitely in advance—after deducting raw boil-off samples—since the throwster pays for all the waste, allowance for which is included in the increased price for throwing.

2. The weights of the raw and thrown silk and the loss by boiling off are definitely known, instead of being estimated or assumed, giving the clearance a mathematical accuracy obtainable in no other way.

3. The use of this method tends to produce a minimum of waste, as a direct loss to the throwster is the result of any waste made in excess of the amount expected.

4. Both the owner and throwster proceed on a known basis regarding the weight of the silk at all stages where the weight is affected, and both parties are on a mutually understood basis where their respective rights can be accurately determined by mathematical processes.

5. The conditioned weight and boil-off of the thrown silk being known, the manufacturer is able to order his weightings with greater precision.

6. It is practically a scientific demonstration as compared with doubtful estimates.

Boil-Off Examples

Below are given some examples from actual tests of both raw and thrown silk, all five bale lots, combination tests, as made by the United States Testing Company.

		Pounds
102.22 pounds reduced to conditioned weight, equals..	100.22	
Deduct raw boil-off sample........................	.22	
Silk sent to throwster, conditioned weight, raw......	100.00	
Raw boil-off 18.40 per cent.........................	18.40	
Conditioned fibre weight of raw silk................		81.60
Silk returned by throwster, conditioned weight thrown	103.00	
Thrown boil-off 22.76 per cent......................	23.44	
Conditioned fibre weight of thrown silk............		79.56
Waste; conditioned fibre weight....................		2.04

The throwster is not charged with the weight of the raw boil-off sample, as this is not sent to him.

Calculation for the Per Cent of Waste

From the above figures the per cent of waste may readily be calculated:

The per cent of waste is equal to the proportion of the conditional fibre weight of waste, 2.04 pounds, to the conditioned fibre weight of raw silk, 81.60 pounds, which equals 2.50 per cent (i. e., 2.04 pounds divided by 81.60 pounds equals 2.50 per cent).

The same result will be obtained if the per cent of waste is based upon the conditioned weight of the raw silk, in which case it is necessary to bring the conditioned fibre weight of waste 2.04 pounds to its weight as conditioned raw silk.

Thus:—

One pound conditioned raw silk, with a boil-off of 18.40 per cent contains .8160 pounds of conditioned fibre silk.

Then.—

2.04 pounds conditioned fibre waste divided by .8160 pounds gives its equivalent as conditioned raw silk, 2.50 pounds.

The per cent of waste then, is equal to the proportion of the conditioned weight of raw silk waste, 2.50 pounds, to the conditioned weight of raw silk, 100 pounds, which again equals 2.50 per cent (i. e., 2.50 pounds divided by 100 pounds equals 2.50 per cent).

Demonstration

The throwing price under the Old Method being 65 cents, and the throwster having estimated that the waste made in throwing will be 2½ per cent and having agreed upon the raw silk price, conditioned weight, at $4.00 per pound, a throwing price on the One Hundred Per Cent. method is figured in the following manner:

Expected waste 2½ per cent. raw silk price; conditioned weight $4.00
Throwing price, conditioned weight (invoice weight price 65 cents plus 2 per cent.).............................. .663

Price for 97½ per cent. of one pound..................$4.663

The throwster, being required to pay for all waste, needs to ascertain what amount must be added in order to cover the cost of the waste, 2½ per cent in this case.

Therefore $4.663 represents the cost of 97½ per cent of 1 pound, and $4.663 divided by .975 pound is the cost of 1 pound of raw silk when thrown..............$4.7825

Stock	Raw Cond. Weight Lbs.	Boil-Off %	Thrown Cond. Weight Lbs.	Boil-Off %	Waste %
Japans	670.98	18.19	693.70	21.53	0.83
"	670.40	18.36	692.27	21.80	1.09
"	687.46	19.70	699.81	22.25	1.44
"	693.28	18.69	715.32	22.68	1.88
"	634.86	19.12	651.95	23.18	2.46
"	680.81	18.24	691.34	22.18	3.35
"	652.36	17.26	659.81	21.49	4.03
Chinas	665.30	16.93	685.18	20.55	1.50
"	553.52	17.34	567.80	21.55	2.65
"	661.34	16.71	670.23	20.39	3.13
"	658.51	17.76	661.45	22.07	4.82

It is proper to state that, since the waste made in throwing is not known until the work is done, and the price for throwing must be quoted in advance, there is room for difference of opinion as to what waste should be figured on each lot. Some chance must be taken in the matter, and experience gained in practice will form a very safe guide.

The payment of the conditioning and testing charges is a matter for mutual arrangement.

La Grande Facon

A method of applying La Grande Facon principles as used in Europe may be stated as follows:

The manufacturer and throwster agree upon a certain per cent of waste the throwster paying the manufacturer for any excess waste that may be made, and under reversed conditions, the manufacturer pays the throwster for saving any waste below the estimated per cent. This is on the principle that if the throwster expends extra labor to diminish waste he should be compensated for it.

The following example will show an adjustment by the European method.

Basis:

Silk sent to throwster, conditioned weight, raw, 100 pounds.

Price for throwing, conditioned weight, 65 cents per pound.

Value of raw silk, conditioned weight, $4 per pound.

Allowance for waste 2½ per cent.

Demonstration

Throwing charge, 100 pounds, conditioned weight, at
65 cents, equals..................................$65.00
2½ per cent. waste allowance on 100 pounds
equals ....2.50 pounds
Actual waste, conditioned weight..........1.25 pounds

Saving in waste ....1.25 pounds at
$4.00 for raw silk.................................. 5.00

Total amount received by throwster.................$70.00

To apply this method under the customs prevailing in America it is necessary to include the throwing cost in the price paid for waste, and to add 2 per cent to the throwing price to bring it to the conditioned weight plus 2 per cent.

Thus:—100 lbs. conditioned weight at....65	cents, equals	$65.00
Plus 2 per cent.........................013	cents, equals	1.30
.663	cents, equals	$66.30

Waste saved
1.25 pounds at $4.00 raw silk,
0.663 throwing

$4.663 equals $ 5.83

On this basis the throwster receives, $72.13

In case where waste made is 2½ per cent, being the actual amount agreed upon, the throwster's charge on 100 pounds, conditioned weight, multiplied by 65 cents, equals $65, plus 2 per cent $1.30, making a total of $66.30, exactly the same as examples A and B.

Advantages of La Grande Facon Method

With the exception of paragraph 1, page 9, all the advantages under the One Hundred Per Cent method also apply.

The cost of thrown silk can be closely calculated provided allowance is made for the weight of the raw boil-off sample and the agreed per cent of waste.

No preliminary calculation of the throwing price is required.

Under either the One Hundred Per Cent, or "La Grande Facon" method of adjustment, the amount paid to the throwster will vary with the actual quantity of waste made, the throwster paying the manufacturer for any excess waste while under reversed conditions, the manufacturer pays the throwster for saving any waste below the estimated percentage.

Comparative Examples Illustrating Adjustment of Clearance Under One Hundred Per Cent. Method

Example 1.

100 pounds, at $0.7825 (based on waste of 2½%)	$78.25
Throwster's expected waste 2.50 per cent.	
Actual waste made 2.50 pounds at $4.7825..	11.95
Under this method the throwster receives when the waste made equals the waste expected.	$66.30

Example 2.

100 pounds, at $0.7825 (based on waste of 2½%)	$78.25
Throwster's expected waste 2.50 per cent.	
Actual waste made 1.00 pounds at $4.7825...	4.78
Under this method the throwster receives when the waste made is 1 per cent instead of the expected 2½ per cent.	$73.47

Example 3.

100 pounds, at $0.7825 (based on waste of 2½%)	$78.25
Throwster's expected waste 2.50 per cent.	
Actual waste made 4.00 pounds at $4.7825...	19.13
Under this method the throwster receives when the waste made is 4 per cent instead of the expected 2½ per cent.	$59.12

The differences appearing in the throwster's bills under the two methods are explained by the fact that the cost of the waste made in throwing (i. e.., 2½ per cent) is included in the One Hundred Per Cent throwing price, but not in La Grande Facon throwing price.

To account for the differences divide the raw silk price \$4.00 plus the throwing price \$0.663, total \$4.663, by .975, which equals \$4.7825. Subtract from this \$4.663 and \$0.1195 is the remainder.

It will be seen that under either method the result is approximately the same.

Comparative Examples Illustrating Adjustment of Clearances Under La Grande Facon Method

Example 1.

100 pounds at \$0.65 plus 2 per cent equals....\$66.30
Agreed waste allowance 2.50 per cent.
Actual waste made 2.50 pounds.

Under this method the throwster receives....\$66.30
when the waste made equals the waste allowed.

Example 2.

100 pounds at \$0.65 plus 2 per cent equals....\$66.30
Agreed waste allowance 2.50 per cent which on 100 pounds equals 2.50 pounds.
Actual waste made 1.00 pounds.
Credit waste saved 1.50 pounds at \$4.663...... 6.99

Under this method the throwster receives....\$73.39
when the waste made is 1 per cent instead of the agreed 2½ per cent.

Example 3.

100 pounds at \$0.65 plus 2 per cent. equals...\$66.30
Agreed waste allowance 2.50 per cent which on 100 pounds equals 2.50 pounds.
Actual waste made 4.00 pounds.
Debit extra waste..1.50 pounds at \$4.663.... 6.99

Under this method the throwster receives....\$59.31
when the waste made is 4 per cent instead of the agreed 2½ per cent.

A simple description of the method may, however, assist in understanding the more complete discussion found in the pamphlet.

There are two fundamental principles involved in the Hundred Per Cent. Method.

First—The throwster is responsible for the amount of waste which he makes and his price per pound for throwing is made with the understanding that he pays for the waste.

The first principle requires that the conditioned weight and boil-off of both the raw and thrown silk should be accurately known. The raw silk must therefore be sent to the Conditioning House before shipping to the throwster and the thrown silk must be returned by the throwster to the Conditioning House before shipment to the manufacturer or dyer.

The throwster's charge is based upon the conditioned weight of the raw silk and he should therefore be furnished with a copy of the conditioning and boil-off certificates.

On a five-bale lot at least two bales of the raw should be conditioned and the remaining three bales shirt weighed. One boil-off taken from the two conditioned bales will furnish a reliable value for the raw. All of the thrown should be sent to the Conditioning House and at least two conditionings and two boil-offs made upon bundles selected by the Conditioning House. These tests will make it possible to compute the clearance upon the clean fibre basis. Each conditioning costs $1.50, each boil-off $1.00 and the shirt weights 25c. per bale, the whole test as outlined therefore consisting of four conditionings, three boil-offs and three shirt weights amounts to $9.75 or about the value of two pounds of thrown. The five bale lot when it is complete represents an investment of approximately $3,000 and a variation of only two pounds (0.3%) in 650 pounds either in the moisture, soap and oil or waste will pay all costs of testing.

The method of computing the clearance can be illustrated best by taking an example involving 100 lbs. of raw silk, conditioned weight.

Suppose the following conditions:

100 lbs. raw silk, conditioned weight—

Cost of raw silk per pound	$3.75
Cost of throwing per pound	.75
Cost of thrown silk per pound	$4.50
Throwster's bill; 100 lbs. @ 75 cts.	$75.00

100 lbs. thrown silk conditioned weight returned—

Raw boil-off	18.50%
Thrown boil-off	20.50%

Therefore,

	Cond. wt.	Boil-off	Fibre weight
Raw	100	18.50%	81.50 lbs.
Thrown	100	20.50%	79.50 lbs.
Waste			2.00 lbs.

Two pounds clean fibre of waste out of 81.50 lbs. of clean fibre equals 2.45% of waste.

$$\text{i. e.} \qquad \frac{2.00}{81.50} \times 100 = 2.45\%$$

Therefore a waste of 2.45% on 100 lbs.=2.45 lbs. gum silk.

The throwster's bill has been charged for the full amount of raw silk received and if he had made no waste he would have returned 102.45 lbs. thrown silk. The thrown silk is worth $4.50 per pound.

100 lbs. @ $0.75=$75.00
2.45 lbs. @ $4.50= 11.02

Throwster receives $63.98

and keeps the 2.45 lbs. of waste.

Advantages of the One Hundred Per Cent Method.

"1st. The cost per pound of the thrown silk is known definitely in advance—after deducting raw boil-off samples—since the throwster pays for all the waste allowance for which is included in the increased price for throwing.

"2nd. The weights of the raw and thrown silk and the loss by boiling off are definitely known, instead of being estimated or assumed, giving the clearance a mathematical accuracy obtainable in no other way.

"3rd. The use of this method tends to produce a minimum of waste, as a direct loss to the throwster is the result of any waste made in excess of the amount expected.

MADE BY

SCRANTON SILK MACHINE CO.

SCRANTON, PA.

—PAT. APPLIED FOR—

TWIST CHART

HOLE	1	2	3	4	5	6	7	8	9
TWIST WITH TRAM GEARS	1	1½	2	2½	3	3½	4	4½	5
TWIST WITH ORGAN. GEARS	4	6	8	10	12	14	16	18	20

SCRANTON SPINNER CHART.
Fig. 72

"4th. Both the owner and throwster proceed on a known basis regarding the weight of the silk at all stages where the weight is affected, and both parties are on a mutually understood basis where their respective rights can be accurately determined by mathematical processes.

"5th. The conditioned weight and boil-off of the thrown silk being known, the manufacturer is able to order his weightings with greater precision.

"6th. It is practically a scientific demonstration as compared with doubtful estimates."

BUILT BY

SCRANTON SILK MACHINE CO.

MANUFACTURERS

THROWING MACHINERY

SCRANTON, PENNA.

PATENTED JUNE 9, 1914

YARDAGE CHART

YARDS	No. TEETH
30,000	682
25,000	568½
22,500	511½
21,000	477½
20,000	454½
15,000	341
10,500	239
10,000	227½
7,500	170½
6,000	136½
5,000	114
4,000	91
3,000	68
2,500	57
2,000	45½
1,000	23
500	11½

44 YARDS PER TOOTH

SCRANTON REEL CHART.
Fig. 73

Nº 9

BELT SPINNER FEED GEAR TABLE

13/16 WHIRL

SPIRAL EVEN GEAR DRIVING & 15 TOOTH WORM GEAR DRIVING

FROM 1 TO 3 TURNS INCLUSIVE USE SPIRAL GEARS AND SINGLE INTERMEDIATE — FROM 3½ TO 6 TURNS INCLUSIVE USE SPIRAL GEARS AND DOUBLE INTERMEDIATE 24 & 48 TEETH 24 TOOTH INTO TAKE UP GEAR

TURNS PER INCH	ON WORM GEAR SHAFT	ON TAKE UP SHAFT
1	25	17
1½	25	26
2	25	35
2½	25	44
3	25	52
3½	25	31
4	25	35
5	25	44
6	25	52

FROM 7 TO 70 TURNS, 15 TOOTH WORM GEAR AND SINGLE INTERMEDIATE.

7	54	18
8	54	20
9	54	23
10	54	25
11	54	28
12	54	30
13	54	33
14	54	35
15	54	38
16	54	40
17	54	43
18	54	45
19	54	48
20	54	50
21	54	53
22	37	38
23	37	40
24	37	41
25	37	43
26	37	45
27	37	46
28	37	48
29	37	50
30	37	52
31	25	36
32	25	37
33	25	38
34	25	40
35	25	41
36	25	42
37	25	43
38	25	44
39	25	45
40	25	47
45	20	42
50	20	47
55	20	52
60	18	51
65	18	55
70	17	56

Note- Test the Twist before using Gears.

The Atwood Machine Co.,

Fig. 74

IMPORTANT - WHEN ORDERING GEARS GIVE Nº OF TABLE!

Nº 15

5B SPINNER FEED GEAR TABLE

13/16 SPINDLE WHIRL – 7/8 FEED ROLL

FROM 1 TO 2 TURNS INCLUSIVE USE 48 TOOTH INTERMEDIATE AND FROM 2½ TO 17 TURNS INCLUSIVE USE 36 TOOTH INTERMEDIATE

TURNS PER INCH		ON BEVEL GEAR SHAFT		ON ROLL SHAFT	
1	TURNS	28	TEETH	21	TEETH
1½	"	28	"	31	"
2	"	28	"	30	"
2½	"	28	"	37	"
3	"	28	"	44	"
3½	"	28	"	51	"
4	"	28	"	59	"
4½	"	21	"	50	"
5	"	21	"	55	"
5½	"	21	"	60	"
6	"	21	"	66	"
6½	"	21	"	51	"
7	"	21	"	55	"
7½	"	21	"	59	"
8	"	21	"	62	"
9	"	25	"	42	"
10	"	25	"	47	"
11	"	25	"	51	"
12	"	25	"	56	"
13	"	25	"	60	"
14	"	21	"	55	"
15	"	21	"	58	"
16	"	21	"	62	"
17	"	21	"	66	"

FOR 1 & 1½ TURNS USE 10 PULLEY ON 1⅛ SHAFT BELOW AND 5" PULLEY ON 5/8 SHAFT ABOVE

FROM 2 TO 6 TURNS INCLUSIVE USE 7" PULLEY ON 1⅛ SHAFT BELOW AND 5" PULLEY ON 5/8 SHAFT ABOVE

FROM 6½ TO 8 TURNS INCLUSIVE USE 8" PULLEY ON 1⅛ SHAFT BELOW AND 5" PULLEY ON 5/8 SHAFT ABOVE

FROM 9 TO 17 TURNS INCLUSIVE USE 5" PULLEY ON 1⅛ SHAFT BELOW AND 10" PULLEY ON 5/8 SHAFT ABOVE.

THE ATWOOD MACHINE CO., STONINGTON, CONN., 1/7/96

NOTE – TEST THE TWIST BEFORE USING GEARS

Fig. 78

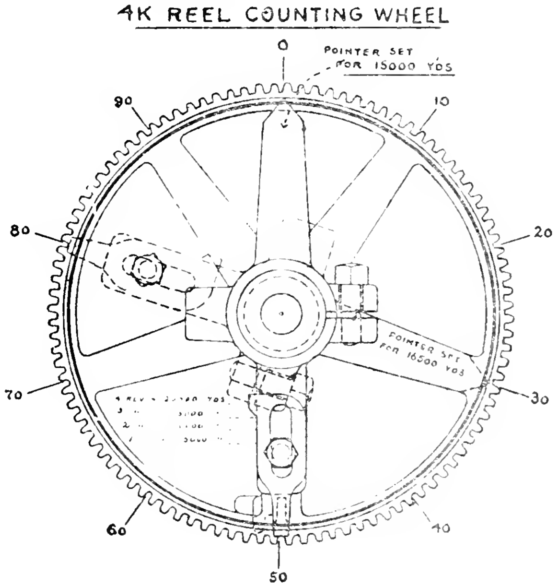


Fig. 76

№ 24

5C-SPINNER

FEED GEAR TABLE

SPINDLE WHIRL $\frac{13}{16}$ DIA.,

EVEN BEV. GEARS AND DOUBLE INTERMEDIATE 24 & 48 TEETH 48 TOOTH INTO UPPER GEAR

TURNS PER INCH SECOND TIME		ON BEVEL GEAR SHAFT		ON ROLL SHAFT	
10	TURNS	21	TEETH	42	TEETH
11	"	21	"	46	"
12	"	21	"	50	"
13	"	21	"	54	"
14	"	21	"	58	"
15	"	21	"	62	"
16	"	16	"	51	"
17	"	16	"	54	"
18	"	16	"	57	"
19	"	16	"	60	"
20	"	16	"	63	"

SECOND TIME DRIVING PULLEY ON CROSS HEAD

5C 155A 10½ DIA. GIVES 14% MORE TWIST ON FIRST TIME
5C 202 10 " " 20% " " " "
5C 161 9 " " 33% " " " "
5C 198 8½ " " 50% " " " "
5C 207 7½ " " 60% " " " "

NOTE—TEST THE TWIST BEFORE USING GEARS

—A.M.C.—

Fig. 75

The counting wheel contains 100 teeth. With reel fly 44″ circumference one revolution of the wheel equals 5000 yds. One tooth equals 50 yds. Before starting the reel run the counting wheel back until the lug on the back of the wheel strikes the lug on the wheel stand. Then if it is desired to reel 5-10-15 or 20 thousand yards, set the pointer at zero on the edge of the wheel, then set the knock off finger to the number of yards required. The graduations for this finger are 1, 2, 3, 4, the revolutions of the wheel. Should it be required to reel between the above numbers, 16,500 yards for example, set the knock off finger on 3, which equals 16,500 yards, then swing the pointer to graduation 30 on the rim of the wheel. These graduations represent the number of teeth. Graduation 30 equals 1500 yards. See that the pointer and knock off finger are fastened securely. Then raise the signal so as to engage the latch below the counting wheel.

Note.—The pointer is shown in two positions, 15,000 and 16,500 yds.

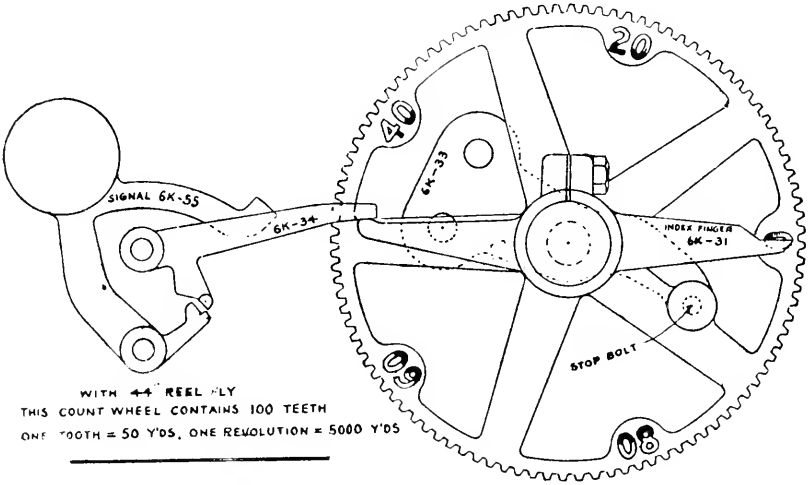


Fig. 77

To set the Count Wheel for 5000—10000—15000 or 20000 yards. Set the index finger 6K-31 with the pointer at zero and fasten same securely. Then run the count wheel out on the screw stud until the index finger 6K-31 engages the knock off finger 6K-34, sufficient to release the signal 6K-55 and allow same to drop. Note the location of the count wheel at this point and turn the wheel back on the stud one revolution for every 5000 yards. Then adjust the stop bolt to engage the plunger in the count wheel at the number of revolutions desired.

To reel between the yardage stated above, for example, take 6000 yards which equals 120 teeth of the count wheel. Set the index finger 6K-31 with the pointer at 20, which designates the number of teeth required in excess of one revolution. Then run the count wheel out on the stud to release the signal. Note the position of the wheel at this point and run it back one revolution and 20 teeth and adjust the stop bolt to engage the plunger in the wheel.

PART III—CHAPTER XIX

HUMIDITY*

Definition: **Humidity is the water vapor (or moisture) mixed with the air in the atmosphere. It is now an accepted fact that the water vapor is simply mixed with the air, and is entirely independent of the presence or absence of it.** The weight of water vapor a given space will hold is entirely and only dependent on the temperature; that is, the amount of vapor is exactly the same whether the air is present or not. The air therefore simply affects the humidity by its temperature.

Water vapor does not spread so rapidly in air as in a vacuous space, as a certain amount of time is required for its diffusion

For example: Suppose that we have a vessel of one cubic foot capacity, and that in this vessel is a perfect vacuum, and that it is placed in a room maintaining exactly and constantly a temperature around the vessel of seventy degrees. Now, if four grains of water are inserted into this chamber, it will rapidly evaporate, and this space will then have a relative humidity of fifty per cent. This vapor would fill the vessel, but if one cubic foot of perfectly dry air at atmospheric pressure was forced into the vessel containing the water vapor it would be found that the water vapor and air would so mix that the pressure in the vessel would still remain at atmospheric pressure and both gases would be contained in the space originally occupied by one.

Use Of Terms. While the above is the accepted theory among scientists, and is really the only theory on which all of the phenomena of evaporation of water can be fully explained, still it is the common usage to consider that "air absorbs moisture." It was, therefore, considered best in submitting this publication to waive claims on scientific exactness of terms in favor of common usage. Use will be made of the accepted terms, namely, "the absorption of water by air," or "saturated air."

Absolute Humidity: Absolute Humidity is the weight of a cubic foot of water vapor at a given temperature and percentage of saturation, and is usually expressed as grains per cubic foot. See Hygrometrical table for the amount of

*By J. I. Lyle, M. E., Past President, American Society of Heating and Ventilating Engineers.

water vapor per cubic foot at different temperatures and percentages of saturation.

Relative Humidity: Relative Humidity is the ratio of the weight of water vapor in a given space to the weight which the same space will hold when fully saturated at the same temperature, and, of course, is expressed in percentage. Under normal conditions the external air has a relative humidity varying from fifty per cent to seventy-five per cent of full saturation, and an absolute humidity depending upon external temperature. When the relative humidity is much above or below these limits ill effects are experienced. The higher the temperature the more noticeable is the effect of moisture deficiency.

Dew Point: Dew Point is the temperature at which saturation is obtained for a given weight of water vapor. In other words, the dew point is the temperature where any reduction in temperature would cause condensation of some of the water vapor in form of dew particles. Any amount of moisture must have a dew point, for the temperature can always be so lowered that condensation must take place by any further reduction.

Measurement Of Humidity: The quantity of moisture mixed with air under different conditions of temperature and degrees of saturation may be measured in several ways. Probably the most convenient of all methods, and the one generally employed, is to observe the temperatures of evaporation. This is the difference between temperature readings of the wet and dry bulb thermometers. Stationary thermometers in relatively stagnant air will not give accurate results. It is necessary that the thermometers be in a strong current of air.

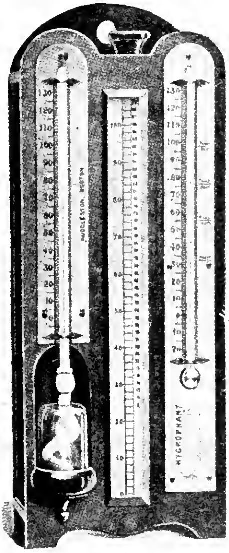
Dry Bulb Thermometer: The dry bulb thermometer should be an accurate instrument, preferably having the divisions marked on the glass tube of the thermometer. It should not be placed too close to the wet bulb, thereby preventing its being affected by the moist and cool air around the wet bulb.

Wet Bulb Thermometer: The wet bulb thermometer, which gives a depressed reading in proportion to the evaporation therefrom, should be covered with soft muslin drawn tightly and neatly over it and thoroughly wetted in clean water. Clean muslin should be used, as the evaporation of the water will soon leave in the meshes a small quantity of solid matter which stiffens it and prevents its ready absorption of moisture.

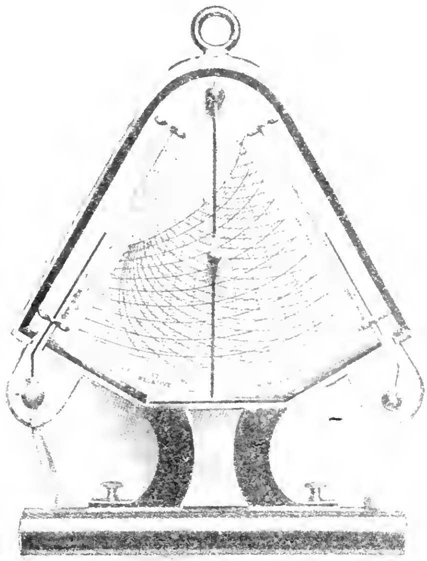
Hygrophant: There are various forms of stationary thermometer instruments on the market, any of which will give very accurate results if the air is agitated around them by means of a fan of some type, and if the wet and dry bulbs are not too close to each other. Fig. 79 shows one type of these instruments.

Hygrodeik: While the hygrophant is the most common instrument used, the hygrodeik is very convenient (Fig. 80), as the relative and absolute humidities can be read direct from the curves without further calculations.

The Sling Psychrometer: This instrument consists of a wet and dry bulb thermometer provided with a handle, as shown in Fig. 81, which permits of the thermometers being whirled rapidly. This instrument is convenient to use, as it



HYGROPHANT
Fig. 79



HYGRODEIK
Fig. 80

may be carried about a room or building by an observer and readings taken easily and rapidly. This is probably the most accurate instrument in general use, and is the one used by the United States Weather Bureau.

Relation of Wet Bulb to Dry Bulb Temperature: A careful study of the government psychrometric tables will show that the ratio of wet bulb temperature rise to dry bulb temperature rise is practically constant for any given percentage of humidity. For any range of temperature, for example, at seventy degrees and sixty per cent humidity, the wet bulb depression is nine degrees, and for each degree rise of the dry bulb the wet bulb must rise .876 degrees in order to maintain the humidity constant at sixty per cent. Similarly at seventy degrees, eighty per cent humidity, the wet bulb depression is four and a half degrees, and for each degree rise in the dry bulb there must be a corresponding rise to .94 degrees in the wet bulb in order to maintain constantly eighty per cent of humidity.

Relation of Dry Bulb, Wet Bulb and Dew Point: The relation between the temperature as shown by dry bulb and wet bulb thermometer, and their relation to the dew point should be thoroughly understood by those expecting to become at all familiar with the requirements for the control of humidity.

Dew point, as previously stated, is the temperature at which saturation is obtained for a given amount of water vapor. In other words, the air is at the dew point when it contains all the moisture that it will hold at a given temperature, and when it is impossible to get the air to absorb more water vapor without raising the temperature. When the air has been reduced to the dew point it will be noted that both wet and dry bulb thermometers register exactly the same. For instance: Air at fifty degrees temperature and one hundred per cent saturation will contain 4.076 grains of moisture per cubic foot. Under this condition the dry bulb thermometer and the wet bulb thermometer will both register fifty degrees. If, however, the air is heated, both thermometers will rise, but the wet bulb temperature will rise more slowly.

The following table shows the relative wet bulb, dry bulb and dew point temperatures in the above sample of air, if heated to the temperatures given:

Dry Bulb Deg.	Wet Bulb Deg.	Dew Point Deg.	Grs. of Moisture per Cu. Ft.	Relative Humidity or Per Cent. Saturation
50	50	50	4.076	100
56	53	50	4.076	80
60	54½	50	4.076	70
65	57	50	4.076	60
70½	59	50	4.076	50
77½	62	50	4.076	40
87	65	50	4.076	30

There are slight errors in the above figures owing to the fact that the expansion of the air and vapor has not been taken into account, but as this is small, it may be neglected.

It will be noted that there is very much smaller rise in the wet bulb temperature than in the dry bulb, and that the dew point remains constant throughout.

For example: When the dry bulb temperature is at sixty-five degrees, or a rise of fifteen degrees, the wet bulb has risen to fifty-seven degrees, or an increase of seven degrees. This gives a difference between the wet and dry bulbs of 65° —57° = 8°, which corresponds to sixty per cent saturation. As the dew point and the amount of moisture per cubic foot bear a definite relation to one another, there being no change in the amount of moisture, the dew point remains unchanged.

Dew Point and Dry Temperatures: The relation of the dew point to the dry bulb temperature is both interesting and necessary to understand the methods of controlling humidity. This relation can be best illustrated by the following tables:

1. Grains of water vapor per cubic foot held by an air when saturated at several temperatures.

Degrees	Grains
63	6.35
68	7.48
73	8.78
78½	10.11
82½	11.80

As the air is saturated, the temperatures given are the dew points for the various amounts of moisture. It is well to bear in mind that any given number of grains of moisture per cubic foot has a fixed and definite dew point or temperature of saturation.

2. Grains of water vapor per cubic foot held by air at eighty per cent relative humidity at several temperatures.

Degrees	Grains
70	6.38
75	7.49
80	8.74
85	10.19
90	11.83

Now compare the weights given for the first temperature in each table. We find that air eighty per cent saturated at seventy degrees holds 6.38 grains per cubic foot, and that air at a dew point of seven degrees lower, or sixty-three degrees, holds 6.35 grains, or practically the same amount.

By comparing the others in succession it will be found that air at eighty per cent. saturated holds the same amount of moisture per cubic foot as air approximately seven degrees lower in temperature but completely saturated.

It could similarly be shown that air seventy per cent saturated contains the same weight of water vapor as air fully saturated 11¼° lower.

From this can be seen that if the difference between the dry bulb temperature and the dew point temperature remains almost constant, then the relative humidity will be practically constant even though the temperature may vary over quite a range.

Therefore, for relative humidity control it matters not what the dry bulb temperature is, nor the temperature of the dew point, but it depends upon the difference between the two.

The dew point depression below the dry bulb temperature for the different percentages of humidity is as follows:

Approximately Per cent.	Degrees
80	7
75	9
70	11¼
65	13¼
60	16¼
55	19

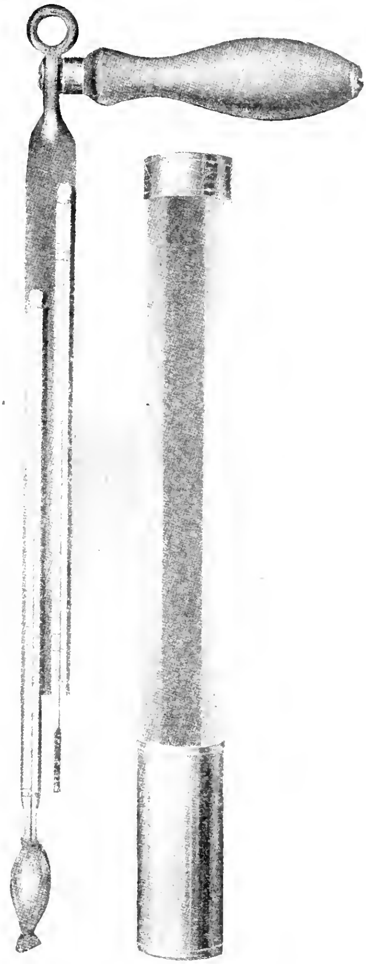
When air is brought in contact with a cold surface the action is exactly the reverse of that given in the preceding discussion; except that if the surface is sufficiently cold, after the dry and wet bulb temperatures reach the dew point, then the dew point will be lowered and particles of water deposited on the surface.

The Action of Wet and Dry Bulb Thermometers During Evaporation: If a cubic foot of air at a temperature of eighty-seven degrees, containing 4.076 grains per cubic foot, with a wet bulb temperature at sixty-five degrees, is passed through a fine spray of heated water, the temperature of which is about fifty degrees, it will absorb the moisture. It will be found then that the dry bulb temperature will immediately begin to fall, but the wet bulb temperature will remain absolutely constant at sixty-five degrees until the dry bulb temperature has dropped to the wet bulb temperature, namely, sixty-five degrees. As the absorption takes place of course the dew point will be gradually rising from fifty degrees to sixty-five degrees when saturation is obtained.

The table shows the relative temperature recorded by the thermometers during the absorption of moisture:

Dry Bulb Deg.	Wet Bulb Deg.	Dew Point Deg.	Grs. of Moisture per Cu. Ft.	Relative Humidity or Per Cent. Saturation
87	65	50	4.08	30
82	65	55	4.65	40
78	65	57	5.13	50
75	65	59	5.61	60
72	65	61	5.96	70
69	65	63	6.18	80
67	65	64	6.52	90
65	65	65	6.78	100

It will be noted in the first line of the table that with 4.08 grains of moisture per cubic foot the dry bulb temperature was eighty-seven degrees, but the absorption of a little over one grain of moisture, increasing the amount to 5.13, lowered the dry bulb temperature to seventy-eight degrees; in other words, at



SLING PSYCHROMETER

Fig. 81

the ordinary temperatures the absorption of one grain of moisture per cubic foot lowers the dry bulb temperature approximately eight and one-half degrees.

Dehumidifying: If air is brought in contact with cold water in sufficient quantities the temperature of the air will be reduced without absorption of

moisture, due entirely to the transmission of the heat from the air to the water. In this case the dry bulb and wet bulb temperatures will both fall gradually until the dew point is reached, at which point, of course, both wet and dry bulb temperatures register the same. The temperature will then continue to fall, depending on the relative amount and temperature of water used; with a reduction of dew point, necessarily a certain amount of moisture will be given up by the air, thus lowering the dew point and reducing the number of grains contained in the air per cubic foot."

HYGROSCOPIC PROPERTIES OF RAW SILK

Raw silk is very hygroscopic, in its greatest state of dryness in the air contains about five and one half per cent of moisture and is susceptible of absorbing eighteen per cent without showing signs of being wet. The saturating point is thirty per cent. In its normal condition in the air it contains 9.91 per cent of moisture or shows a regain of eleven per cent.

$$(100 : 11 = \frac{11 \times 100}{111} = 9.91\%).$$

This is the standard adopted in the United States.

*"The quality of water that a hygroscopic material in equilibrium with the surrounding air contains is a function of two variables, the relative humidity of the air and the temperature. This is doubtless well known to the greater number of physicists and chemists, but is less generally known than is commonly supposed; for requests are frequently made to have the humidity of this or that substance determined without giving the value of the two variables on which this humidity actually depends. We find for example in recent books such statements as the following: silk in a dry room retains such a percentage of humidity and the exact figure is given without any reference to the hygroscopic condition or the temperature of the atmosphere. Now in a room called dry, the hygroscopic condition, as well as the temperature, may vary within widely separated limits, as we shall see, the degree of humidity in silk to vary from one to two or three fold. There are also writers who speak of the natural humidity acquired by cotton exposed to the air and state the exact degree, as if such a degree could be fixed regardless of other factors. Such writers illustrate the need of directing attention to the conditions on which the humidity of textile materials depends, and to determine those conditions.

When, therefore, an equilibrium of humidity is established between a hygroscopic material and the surrounding air, there is at each temperature a relation between the humidity of the material and the relative degree of humidity of the air, so that a given value for the latter corresponds to a certain value for the former. It is this relation that I have studied.

*By Th. Schloesing, in Textile World Record. Translated by Samuel S. Dale.

Relative humidity for various dry and wet bulb temperatures of the Sling Psychrometer. Barometric pressure thirty inches.

Reading of Dry Bulb Thermometer	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0
60	94	89	84	78	73	68	63	58	53	49	44	40	35	31	27	22	18
61	94	89	84	79	74	68	64	59	54	50	45	40	36	32	28	24	20
62	94	89	84	79	74	69	64	60	55	50	46	41	37	33	29	25	21
63	95	90	84	79	74	70	65	60	56	51	47	42	38	34	30	26	22
64	95	90	85	79	75	70	66	61	56	52	48	43	39	35	31	27	23
65	95	90	85	80	75	70	66	62	57	53	48	44	40	36	32	28	25
66	95	90	85	80	76	71	66	62	58	53	49	45	41	37	33	29	26
67	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34	30	27
68	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35	31	28
69	95	90	86	81	77	72	68	64	59	55	51	47	44	40	36	32	29
70	95	90	86	81	77	72	68	64	60	56	52	48	44	40	37	33	30
71	95	90	86	82	77	73	69	64	60	56	53	49	45	41	38	34	31
72	95	91	86	82	78	73	69	65	61	57	53	49	46	42	39	35	32
73	95	91	86	82	78	73	69	65	61	58	54	50	46	43	40	36	33
74	95	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37	34
75	96	91	87	82	78	74	70	66	63	59	55	51	48	44	41	38	34
76	96	91	87	83	78	74	70	67	63	59	55	52	48	45	42	38	35
77	96	91	87	83	79	75	71	67	63	60	56	52	49	46	42	39	36
78	96	91	87	83	79	75	71	67	64	60	57	53	50	46	43	40	37
79	96	91	87	83	79	75	71	68	64	60	57	54	50	47	44	41	37
80	96	91	87	83	79	76	72	68	64	61	57	54	51	47	44	41	38
82	96	92	88	84	80	76	72	69	65	62	58	55	52	49	46	43	40
84	96	92	88	84	80	77	73	70	66	63	59	56	53	50	47	44	41
86	96	92	88	85	81	77	74	70	67	63	60	57	54	51	48	45	42
88	96	92	88	85	81	78	74	71	67	64	61	58	55	52	49	46	43
90	96	92	89	85	81	78	75	71	68	65	62	59	56	53	50	47	44
92	96	92	89	85	82	78	75	72	69	65	62	59	57	54	51	48	45
94	96	93	89	86	82	79	75	72	69	66	63	60	57	54	52	49	46
96	96	93	89	86	82	79	76	73	70	67	64	61	58	55	53	50	47
98	96	93	89	86	83	79	76	73	70	67	64	61	59	56	53	51	48
100	96	93	90	86	83	80	77	74	71	68	65	62	59	57	54	52	49

HYGROMETRICAL TABLES

Adapted to the use of the dry and wet bulb thermometer. Compiled from tables of James Glaisher, F. R. S. Published by the American Moistening Co. Heavy type indicates limit of English Factory Law.

Reading of Thermometer. Dry F.	Wet F.	Degree of Humidity. %	Vapour in a Cubic Foot of Air. Grs.
60	50	50	2·9
	51	54	3·1
	52	58	3·3
	53	62	3·6
	54	66	3·8
	55	71	4·1
	56	76	4·4
	57	82	4·7
	58	**88**	**5·1**
	59	94	5·4
	60	100	5·8
61	50	47	2·8
	51	50	3·0
	52	54	3·2
	53	58	3·5
	54	62	3·7
	55	67	4·0
	56	72	4·3
	57	77	4·6
	58	82	4·9
	59	**88**	**5·2**
	60	94	5·6
	61	100	6·0
62	50	44	2·7
	51	47	2·9
	52	50	3·1
	53	54	3·4
	54	58	3·6
	55	62	3·9
	56	67	4·1
	57	72	4·4
	58	77	4·7
	59	82	5·1
	60	**88**	**5·4**
	61	94	5·8
	62	100	6·2
63	51	44	2·8
	52	47	3·0
	53	51	3·3
	54	55	3·5
	55	59	3·7
	56	63	4·0
	57	67	4·3
	58	72	4·6
	59	77	4·9
	60	82	5·2
	61	**88**	**5·6**
	62	94	6·0
	63	100	6·4
64	52	45	3·0
	53	48	3·2
	54	51	3·4
	55	55	3·6
	56	59	3·9
	57	63	4·2
	58	67	4·5
	59	72	4·8
	60	77	5·1
	61	82	5·4
	62	**88**	**5·8**
	63	94	6·2
	64	100	6·6
65	53	45	3·1

Reading of Thermometer. Dry F.	Wet F.	Degree of Humidity. %	Vapour in a Cubic Foot of Air. Grs.
65	54	48	3·3
	55	51	3·5
	56	55	3·8
	57	59	4·0
	58	63	4·3
	59	68	4·6
	60	73	4·9
	61	78	5·3
	62	83	5·6
	63	**88**	**6·0**
	64	94	6·4
	65	100	6·8
66	54	45	3·2
	55	48	3·4
	56	52	3·7
	57	56	3·9
	58	60	4·2
	59	64	4·5
	60	68	4·8
	61	73	5·1
	62	78	5·5
	63	83	5·8
	64	**88**	**6·2**
	65	94	6·6
	66	100	7·0
67	55	46	3·3
	56	49	3·6
	57	52	3·8
	58	56	4·1
	59	60	4·4
	60	64	4·7
	61	68	5·0
	62	73	5·3
	63	78	5·6
	64	83	6·0
	65	**88**	**6·4**
	66	94	6·8
	67	100	7·3
68	56	46	3·5
	57	49	3·7
	58	52	4·0
	59	56	4·2
	60	60	4·5
	61	64	4·8
	62	68	5·2
	63	73	5·5
	64	78	5·8
	65	83	6·2
	66	**88**	**6·6**
	67	94	7·1
	68	100	7·5
69	57	47	3·6
	58	50	3·9
	59	53	4·1
	60	56	4·4
	61	60	4·7
	62	64	5·0
	63	68	5·3
	64	73	5·7
	65	78	6·1
	66	83	6·5
	67	**88**	**6·9**
	68	94	7·3

Reading of Thermometer. Dry F.	Wet F.	Degree of Humidity. %	Vapour in a Cubic Foot of Air. Grs.
69	69	100	7·8
70	58	47	3·8
	59	50	4·0
	60	53	4·3
	61	57	4·6
	62	61	4·9
	63	65	5·2
	64	69	5·5
	65	73	5·9
	66	78	6·3
	67	83	6·7
	68	**88**	**7·1**
	69	94	7·5
	70	100	8·0
71	59	47	3·9
	60	50	4·2
	61	53	4·4
	62	57	4·7
	63	61	5·1
	64	65	5·4
	65	69	5·7
	66	73	6·1
	67	78	6·5
	68	83	6·9
	68½	**85½**	**7·1**
	69	88	7·3
	70	94	7·8
	71	100	8·3
72	59	45	3·8
	60	48	4·1
	61	51	4·4
	62	54	4·7
	63	57	5·0
	64	61	5·3
	65	65	5·6
	66	69	5·9
	67	74	6·3
	68	79	6·7
	69	**84**	**7·1**
	70	89	7·6
	71	94	8·0
	72	100	8·5
73	57	37	3·3
	58	40	3·5
	59	42	3·7
	60	45	4·0
	61	48	4·2
	62	51	4·5
	63	54	4·8
	64	58	5·1
	65	62	5·4
	66	66	5·8
	67	70	6·2
	68	74	6·6
	69	79	7·0
	70	**84**	**7·4**
	71	89	7·8
	72	94	8·3
	73	100	8·8
74	56	33	3·0
	57	35	3·2
	58	37	3·4

Reading of Thermometer. Dry F.	Wet F.	Degree of Humidity. %	Vapour in a Cubic Foot of Air. Grs.
74	59	40	3·6
	60	43	3·9
	61	45	4·1
	62	48	4·4
	63	52	4·7
	64	55	5·0
	65	58	5·3
	66	62	5·6
	67	66	6·0
	68	70	6·4
	69	74	6·8
	70	79	7·2
	70½	**81½**	**7·4**
	71	84	7·6
	72	89	8·1
	73	94	8·6
	74	100	9·1
75	56	31	2·9
	57	33	3·1
	58	36	3·3
	59	38	3·6
	60	40	3·8
	61	43	4·0
	62	46	4·3
	63	49	4·6
	64	52	4·9
	65	55	5·2
	66	58	5·5
	67	62	5·8
	68	66	6·2
	69	70	6·6
	70	74	7·0
	71	79	7·4
	71½	**81½**	**7·65**
	72	84	7·9
	73	89	8·4
	74	94	8·9
	75	100	9·4
76	58	34	3·3
	59	36	3·5
	60	38	3·7
	61	40	3·9
	62	43	4·2
	63	46	4·5
	64	49	4·8
	65	52	5·1
	66	55	5·4
	67	59	5·7
	68	63	6·1
	69	67	6·4
	70	71	6·8
	71	75	7·2
	72	**79**	**7·7**
	73	84	8·2
	74	89	8·6
	75	94	9·2
	76	100	9·7
77	59	34	3·4
	60	36	3·6
	61	38	3·9
	62	41	4·1
	63	44	4·3
	64	47	4·6
	65	50	4·9
	66	53	5·3
	67	56	5·6

Reading of Thermometer. Dry F.	Wet F.	Degree of Humidity. %	Vapour in a Cubic Foot of Air. Grs.
77	68	59	5·9
	69	63	6·3
	70	67	6·7
	71	71	7·1
	72	75	7·5
	73	**79**	**8·0**
	74	84	8·4
	75	89	8·9
	76	94	9·5
	77	100	10·0
78	60	35	3·5
	61	37	3·8
	62	39	4·0
	63	41	4·3
	64	44	4·5
	65	47	4·8
	66	50	5·1
	67	53	5·5
	68	56	5·8
	69	59	6·2
	70	63	6·5
	71	67	6·9
	72	71	7·3
	73	75	7·8
	73½	**77**	**8·0**
	74	79	8·2
	75	84	8·7
	76	89	9·2
	77	94	9·7
	78	100	10·3
79	60	32	3·5
	61	35	3·7
	62	37	3·9
	63	39	4·2
	64	42	4·4
	65	44	4·7
	66	47	5·0
	67	50	5·3
	68	53	5·6
	69	56	6·0
	70	59	6·4
	71	63	6·8
	72	67	7·2
	73	71	7·6
	74	75	8·0
	74½	**77½**	**8·25**
	75	80	8·5
	76	85	9·0
	77	90	9·5
	78	95	10·1
	79	100	10·6
80	61	33	3·6
	62	35	3·8
	63	37	4·1
	64	39	4·3
	65	41	4·6
	66	44	4·9
	67	47	5·2
	68	50	5·5
	69	53	5·8
	70	56	6·2
	71	59	6·6
	72	63	7·0
	73	67	7·4
	74	71	7·8
	75	75	8·3
	75½	**77½**	**8·55**

Reading of Thermometer. Dry F.	Wet F.	Degree of Humidity. %	Vapour in a Cubic Foot of Air. Grs.
80	76	80	8·8
	77	85	9·3
	78	90	9·8
	79	95	10·4
	80	100	11·0
81	62	33	3·7
	63	35	4·0
	64	37	4·2
	65	39	4·5
	66	41	4·8
	67	44	5·1
	68	47	5·4
	69	50	5·7
	70	53	6·0
	71	56	6·4
	72	60	6·8
	73	64	7·2
	74	68	7·6
	75	72	8·1
	76	**76**	**8·6**
	77	80	9·1
	78	85	9·5
	79	90	10·1
	80	95	10·7
	81	100	11·3
82	62	31	3·6
	63	33	3·9
	64	35	4·1
	65	38	4·4
	66	40	4·7
	67	42	4·9
	68	45	5·2
	69	48	5·6
	70	51	5·9
	71	54	6·3
	72	57	6·7
	73	60	7·1
	74	64	7·5
	75	68	7·9
	76	72	8·4
	76½	**74**	**8·65**
	77	76	8·9
	78	80	9·4
	79	85	9·9
	80	90	10·5
	81	95	11·1
	82	100	11·7
83	62	30	3·6
	63	32	3·8
	64	34	4·0
	65	36	4·3
	66	38	4·6
	67	40	4·8
	68	42	5·1
	69	45	5·4
	70	48	5·8
	71	51	6·1
	72	54	6·5
	73	57	6·9
	74	60	7·3
	75	64	7·7
	76	68	8·2
	77	72	8·6
	77½	**74**	**8·85**
	78	76	9·1
	79	80	9·7

HYGROMETRICAL TABLES

Adapted to the use of the dry and wet bulb thermometer. Compiled from tables of James Glaisher, F. R. S. Published by the American Moistening Co. Heavy type indicates limit of English Factory Law.

Reading of Thermometer. Dry	Reading of Thermometer. Wet	Degree of Humidity.	Vapour in a Cubic Foot of Air.
F.	F.	%	Grs.
83	80	85	10·2
	81	90	10·8
	82	95	11 7
	83	100	12 0
84	62	28	3 5
	63	30	3 7
	64	32	4 0
	65	34	4·2
	66	36	4·5
	67	38	4·7
	68	41	5·0
	69	43	5·3
	70	45	5·6
	71	48	6 0
	72	51	6·3
	73	54	6 7
	74	57	7·1
	75	60	7·5
	76	64	8 0
	77	68	8·5
	78	**72**	**8 9**
	79	76	9 4
	80	80	10·0
	81	85	10·5
	82	90	11 1
	83	95	11·7
	84	100	12·4
85	63	28	3 6
	64	30	3 8
	65	32	4·1
	66	34	4 3
	67	36	4 6
	68	38	4·9
	69	40	5 2
	70	43	5·5
	71	46	5 9
	72	49	6 2
	73	52	6·6
	74	55	7 0
	75	58	7 4
	76	61	7·8
	77	64	8 3
	78	68	8 7
	79	**72**	**9 2**
	80	76	9·7
	81	80	10·3
	82	85	10 9
	83	90	11·5
	84	95	12 1
	85	100	12 8
86	63	27	3 5
	64	28	3·7
	65	30	4 0
	66	32	4 2
	67	34	4·5
	68	36	4 8
	69	38	5·1
	70	40	5·4
	71	43	5·7
	72	46	6·1
	73	49	6·4
	74	52	6·8
	75	55	7·2
	76	58	7 6
	77	61	8·1
	78	64	8·5

Reading of Thermometer. Dry	Reading of Thermometer. Wet	Degree of Humidity.	Vapour in a Cubic Foot of Air.
F.	F.	%	Grs.
86	79	68	9 0
	80	**72**	**9·5**
	81	76	10·1
	82	80	10 6
	83	85	11 2
	84	90	11·8
	85	95	12 5
	86	100	13 2
87	64	27	3·7
	65	29	3 9
	66	31	4 2
	67	33	4 4
	68	35	4 7
	69	37	5 0
	70	39	5 3
	71	41	5 6
	72	43	5·9
	73	46	6 3
	74	49	6·6
	75	52	7·0
	76	55	7·4
	77	58	7 9
	78	61	8 3
	79	65	8·8
	80	69	9·3
	80½	**71**	**9·55**
	81	73	9 8
	82	77	10 4
	83	81	11·0
	84	85	11·6
	85	90	12·2
	86	95	12 9
	87	100	13 6
88	65	27	3 8
	66	29	4·1
	67	31	4 3
	68	33	4 6
	69	35	4 9
	70	37	5 2
	71	39	5·5
	72	41	5 8
	73	43	6 1
	74	46	6 5
	75	49	6 9
	76	52	7 3
	77	55	7·7
	78	58	8·1
	79	61	8 6
	80	65	9·1
	81	69	9 6
	81½	**71**	**9 9**
	82	73	10 2
	83	77	10 8
	84	81	11 4
	85	85	12 0
	86	90	12 6
	87	95	13 3
	88	100	14 0
89	66	28	4 0
	67	29	4 2
	68	31	4 5
	69	33	4 8
	70	35	5 1
	71	37	5 4
	72	39	5 7
	73	41	6·0
	74	43	6 4

Reading of Thermometer. Dry	Reading of Thermometer. Wet	Degree of Humidity.	Vapour in a Cubic Foot of Air.
F.	F.	%	Grs.
89	75	46	6 7
	76	49	7 1
	77	52	7 5
	78	55	8 0
	79	58	8·4
	80	61	8 9
	81	65	9 4
	82	69	10·0
	82½	**71**	**10·25**
	83	73	10·5
	84	77	11·1
	85	81	11 7
	86	85	12 3
	87	90	13 0
	88	95	13 7
	89	100	14 4
90	67	28	4·2
	68	30	4·4
	69	32	4·7
	70	34	5·0
	71	36	5·3
	72	38	5 6
	73	40	5 9
	74	42	6·2
	75	44	6 6
	76	47	7 0
	77	50	7 4
	78	53	7 8
	79	56	8·3
	80	59	8 7
	81	62	9 2
	82	65	9·7
	83	**69**	**10·3**
	84	73	10 8
	85	77	11·4
	86	81	12 1
	87	85	12 7
	88	90	13.4
	89	95	14.1
	90	100	14 8
91	68	28	4 3
	69	30	4·5
	70	32	4 8
	71	34	5·1
	72	36	5·5
	73	38	5·8
	74	40	6·1
	75	42	6·5
	76	44	6 8
	77	47	7·2
	78	50	7 7
	79	53	8·1
	80	56	8 5
	81	59	9·0
	82	62	9 5
	83	66	10·1
	83½	**68**	**10·35**
	84	70	10·6
	85	74	11 2
	86	78	11·8
	87	82	12 5
	88	86	13 1
	89	90	13 8
	90	95	14·5
	91	100	15 3
92	69	28	4 5

Reading of Thermometer. Dry	Reading of Thermometer. Wet	Degree of Humidity.	Vapour in a Cubic Foot of Air.
F.	F.	%	Grs.
92	70	30	4 8
	71	32	5 0
	72	34	5 3
	73	36	5·7
	74	38	6 0
	75	41	6 3
	76	43	6 7
	77	45	7 1
	78	47	7 5
	79	50	7 9
	80	53	8 3
	81	56	8 8
	82	59	9 3
	83	62	9 9
	84	66	10·4
	84½	**68**	**10 7**
	85	70	11·0
	86	73	11 6
	87	77	12·2
	88	81	12·8
	89	85	13 5
	90	90	14 2
	91	95	14 9
	92	100	15 7
93	70	29	4 7
	71	30	5 0
	72	32	5 2
	73	34	5 5
	74	36	5 9
	75	38	6 2
	76	40	6 6
	77	42	6 9
	78	45	7 4
	79	48	7.8
	80	51	8 2
	81	54	8 7
	82	57	9 1
	83	60	9 6
	84	63	10 2
	85	66	10 7
	85½	**68**	**11·0**
	86	70	11 3
	87	74	11 9
	88	78	12 6
	89	82	13 3
	90	86	14 0
	91	90	14·7
	92	95	15·4
	93	100	16·2
94	71	29	4 9
	72	31	5·1
	73	33	5·4
	74	35	5·7
	75	37	6·1
	76	39	6·4
	77	41	6·8
	78	43	7 2
	79	45	7·6
	80	48	8 0
	81	51	8 5
	82	54	9 0
	83	57	9 5
	84	60	10 6
	85	63	10 5
	86	**66**	**11·1**
	87	70	11·7
	88	74	12 8
	89	78	13·0

Reading of Thermometer. Dry	Reading of Thermometer. Wet	Degree of Humidity.	Vapour in a Cubic Foot of Air.
F.	F.	%	Grs.
94	90	82	13·7
	91	86	14 4
	92	90	15·1
	93	95	15 9
	94	100	16 7
95	72	30	5 0
	73	31	5·3
	74	33	5 6
	75	35	6 0
	76	37	6 3
	77	39	6·7
	78	41	7 1
	79	43	7 5
	80	45	7 9
	81	48	8 3
	82	51	8 8
	83	54	9 3
	84	57	9 8
	85	60	10 3
	86	63	10 9
	87	**66**	**11·5**
	88	70	12·1
	89	74	12·7
	90	78	13 4
	91	82	14 1
	92	86	14 8
	93	91	15 5
	94	95	16·8
	95	100	17 2
96	73	30	5·3
	74	31	5 6
	75	33	5 9
	76	35	6 2
	77	37	6 5
	78	39	6 9
	79	41	7·3
	80	43	7·7
	81	46	8 2
	82	49	8 6
	83	52	9 1
	84	54	9 6
	85	57	10 1
	86	60	10 7
	87	63	11·2
	88	**66**	**11 8**
	89	70	12 4
	90	74	13·1
	91	78	13 8
	92	82	14·5
	93	86	15 2
	94	90	16 0
	95	95	16 8
	96	100	17·7
97	74	30	5·5
	75	31	5 8
	76	33	6·1
	77	35	6·4
	78	37	6·8
	79	39	7 2
	80	42	7·6
	81	44	8 0
	82	46	8·4
	83	49	8·9
	84	52	9·4
	85	54	9·9
	86	57	10.4

Reading of Thermometer. Dry	Reading of Thermometer. Wet	Degree of Humidity.	Vapour in a Cubic Foot of Air.
F.	F.	%	Grs.
97	87	60	11 0
	88	64	11·6
	88½	**65½**	**11·9**
	89	67	12 2
	90	70	12 8
	91	74	13 5
	92	78	14 2
	93	82	14 9
	94	86	15 7
	95	90	16·5
	96	95	17 3
	97	100	18 2
98	75	30	5·7
	76	32	6·0
	77	34	6·3
	78	86	6·7
	79	38	7.1
	80	40	7·4
	81	42	7 8
	82	44	8·3
	83	46	8 7
	84	49	9 2
	85	52	9 7
	86	55	10·2
	87	58	10 8
	88	61	11 4
	89	**64**	**12.0**
	90	67	12 6
	91	70	13 2
	92	74	13 9
	93	78	14 6
	94	82	15 4
	95	86	16 2
	96	90	17 0
	97	95	17·8
	98	100	18·7
99	76	31	5 9
	77	32	6·2
	78	34	6 6
	79	36	6 9
	80	38	7 3
	81	40	7·7
	82	42	8 1
	83	44	8·6
	84	46	9 0
	85	49	9 5
	86	52	10 0
	87	55	10 5
	88	58	11·1
	89	61	11·7
	90	**64**	**12 3**
	91	67	13·0
	92	71	13 7
	93	75	14 4
	94	79	15·1
	95	88	15·9
	96	87	16 7
	97	91	17 5
	98	95	18 4
	99	100	19 3
100	76	29	5 8
	77	30	6 1
	78	32	6 4
	79	34	6 8
	80	36	7·2
	81	38	7 6

Following are results of experiments conducted by Th. Schloesing Fils showing the amount of moisture absorbed by silk at various temperatures and relative humidity.

HUMIDIFYING.

Raw Cevennes Silk

Parts Water per 100 Parts Dry Material.	Temperature Centigrade.	Relative Humidity of the Air.
7.5	12	31.6
7.5	24	35.1
7.5	35	38.3
9.7	12	50.5
9.7	24	56.3
9.7	35	61.7
14.2	12	75.0
14.2	24	78.6
14.2	35	81.9
16.5	12	83.9
16.5	24	86.1
16.5	35	88.1
25.6	12	94.8
25.6	24	95.0
25.6	35	95.1

Boiled Off Cevennes Silk.

Parts Water per 100 Parts Dry Material.	Temperature Centigrade.	Relative Humidity of the Air.
6.55	12	27.9
6.55	24	32.6
6.55	35	37.0
11.6	12	65.3
11.6	24	71.3
11.6	35	76.8
14.65	12	79.6
14.65	24	82.2
14.65	35	84.7
22.0	12	94.3
22.0	24	95.1
22.0	35	95.6

Raw China Silk.

Parts Water per 100 Parts Dry Material.	Temperature Centigrade.	Relative Humidity of the Air.
7.4	12	34.1
7.4	24	36.2
7.4	35	38.2
12.35	12	67.3
12.35	24	72.5
12.35	35	77.3
17.1	12	86.8
17.1	24	88.3
17.1	35	89.5
23.8	12	95.2
23.8	24	96.0
23.8	35	96.8

Boiled Off China Silk.

Parts Water per 100 Parts Dry Material.	Temperature Centigrade.	Relative Humidity of the Air.
6.1	12	31.1
6.1	24	33.6
6.1	35	36.0
11.65	12	68.9
11.65	24	73.7
11.65	35	78.2
14.95	12	83.6
14.95	24	85.2
14.95	35	86.6
23.3	12	94 1
23.3	24	94.5
23.3	35	94.8

Japan Raw Silk.

Regain in per cent. at seventy degrees Fahrenheit

(Values interpolated from a curve plotted from experimental data furnished by S. W. Cramer).

Humidity %	Regain %	Humidity %	Regain %
20	7.0	60	11.2
25	7.7	65	11.7
30	8.4	70	12.3
35	9.0	75	13.0
40	9.5	80	13.7
45	10.0	85	14.5
50	10.4	90	15.4
55	10.8		

The Effect of Humidity on Raw Silk.

A raw silk thread containing from twelve to fourteen per cent moisture is from fifteen to twenty-five per cent more ductile than when in a dry state containing not over eight per cent of moisture and its permanent elongation is four per cent. greater in the first named condition than in the latter. In other words, with about fourteen per cent of moisture, a thread twenty inches long if stretched to twenty-three inches would recede about seven per cent and remain a thread about twenty-one and a half inches long, while the same thread if stretched in a dry condition to twenty-three inches would recede only about three per cent or remain a thread twenty-two and a half inches long.

Ductility is that quality of a silk thread that causes it to stretch out under tension. An elastic thread is one that springs back to, or near, its original length on release of the tension.

The sericin surrounding the fibroin of a silk thread is a silk glue; take a thin sheet of glue, when dry it breaks off on bending but when moist it can hardly be broken; it also stretches out considerably before breaking apart and stands all kinds of bending and twisting. I will use the term Ductility as it applies to stretching out and pliability to bending and twisting.

Because of this silk glue a raw silk thread acts the same way; under dry conditions the sericin becomes hard and brittle more or less according to the nature of the silk or the cohesiveness of the sericin. Under tension it breaks off quickly because the gum will not expand to its full capacity; on bending or twisting the gum presents a sharp edge, same as cutting paper with a sharp edge ruler, which partly cuts the thread, and the breaks become more frequent.

Under humid conditions the sericin becomes soft and pliable and the thread stands a great amount of bending and twisting as the sharp edge no more appears. The hard sericin of Chinas and the hardening effect by dry atmosphere appears to be the cause of very poor single weaving and spinning results when worked with a low humidity. In my opinion the pliability has more to do with the spinning and weaving qualities than the ductility and the cutting edge of the hard gum, the real cause.

TABLE OF REGAIN OF CHINA RAW SILK.

Values Interpolated by W. P. Seem from a curve made by Th. Schloesing Fils.
Degrees Fahrenheit.

Degrees Fahrenheit.

% Humidity	55	60	65	70	75	80	85	90	95
36	7.70	7.61	7.54	7.47	7.4				
38	8.	7.90	7.80	7.70	7.6	7.55	7.50	7.45	7.4
40	8.30	8.20	8.10	8.	7.9	7.82	7.74	7.67	7.6
42	8.60	8.50	8.40	8.30	8.2	8.12	8.04	7.97	7.9
44	8.90	8.80	6.69	8.58	8.47	8.40	8.32	8.24	8.16
46	9.20	9.09	8.97	8.85	8.73	8.64	8.56	8.48	8.40
48	9.50	9.36	9.24	9.10	9.	8.90	8.80	8.70	8.60
50	9.80	9.66	9.53	9.40	9.27	9.16	9.08	9.	8.92
52	10.10	9.96	9.82	9.68	9.54	9.44	9.35	9.26	9.17
54	10.40	10.25	10.10	9.95	9.80	9.70	9.61	9.52	9.43
56	10.70	10.54	10.38	10.22	10.07	9.98	9.88	9.78	9.68
58	11.	10.82	10.66	10.50	10.34	10.23	10.13	10.03	9.93
60	11.30	11.13	10.96	10.78	10.60	10.49	10.39	10.29	10.19
62	11.60	11.42	11.23	11.05	10.87	10.77	10.66	10.55	10.44
64	11.90	11.71	11.52	11.33	11.14	11.03	10.92	10.81	10.70
66	12.20	12.01	11.87	11.61	11.41	11.31	11.19	11.07	10.95
68	12.60	12.39	12.14	11.91	11.68	11.56	11.44	11.32	11.20
70	13.06	12.78	12.50	12.22	11.94	11.82	11.70	11.58	11.46
72	13.54	13.22	12.87	12.54	12.21	12.07	11.95	11.83	11.71
74	14.01	13.75	13.39	13.03	12.67	12.50	12.32	12.14	11.96
76	14.50	14.20	13.90	13.60	13.30	13.03	12.76	12.49	12.22
78	14.96	14.70	14.45	14.20	13.95	13.63	13.32	13.01	12.7
80	15.44	15.22	15.01	14.79	14.57	14.28	14.	13.72	13.44
82	15.91	15.74	15.56	15.38	15.20	14.92	14.67	14.42	14.17
84	16.39	16.25	16.11	15.97	15.83	15.59	15.36	15.13	14.90
86	16.86	16.76	16.66	16.56	16.46	16.26	16.06	15.84	15.63
88	17.9	17.70	17.58	17.30	17.1	16.91	16.73	16.54	16.36
90	19.6	19.36	19.14	18.92	18.7	18.30	17.90	17.50	17.1
92	21.3	21.10	20.9	20.70	20.5	20.12	19.75	19.38	19.01
94	23.	22.79	22.58	22.35	22.13	21.82	21.52	21.22	20.92
96					23.8	23.63	23.38	23.13	22.88

I will try and prove this statement with these facts:

Boiled off silk is about twenty-five per cent less ductile than raw, but it is exceedingly pliable. Fifty-five to sixty per cent relative humidity at seventy degrees Fahrenheit appears all that is desired for skein-dyed thread, just enough to lay the fibres or overcome the static electricity which causes the fibre to fly out in all directions and catch on anything rough making all kinds of trouble.

On raw silk we have the silk gum surrounding the thread which makes it stiff and a higher humidity is necessary to soften same properly and make the thread pliable.

My experiments show that the breaks in spinning increase very rapidly when the relative humidity gets under fifty-five per cent. and slowly decrease as the humidity is raised to sixty-five per cent at seventy-five degrees Fahrenheit. Beyond that very little gain is realized, but a silk may become even ten per cent more ductile if kept in a humidity of eighty per cent, but the breaks do not decrease; therefore it appears that silk in its normal condition with a regain of eleven per cent, nine and ninety-one hundredths per cent of moisture, gives the maximum results as far as ductility and pliability are concerned.

I find that silk with a regain of from eleven to eleven and one-half per cent gives good spinning results and extreme humid conditions in hot spinning rooms can thus be avoided.

According to a table compiled from Schloesing's experiments a regain of about eleven and one-half per cent. on China raw would occur at the following temperatures.

65 deg. F., 64 per cent. relative humidity.
70 deg. F., 65 per cent. relative humidity.
75 deg. F., 67 per cent. relative humidity.
80 deg. F., 68 per cent. relative humidity.
85 deg. F., 69 per cent. relative humidity.
90 deg. F., 69 per cent. relative humidity.
95 deg. F., 70 per cent. relative humidity.

S. W. Cramer's table of regain on Japan silk shows eleven five tenths per cent at seventy degrees Fahrenheit at sixty-three per cent relative humidity.

My experience has proven that operatives are inefficient when working under a higher temperature and relative humidity than the following:

Temperature, Fahrenheit.	Relative Humidity.	Limit of English Factory Law.
70°	75%	88%
75°	75%	81½%
80°	70%	77½%
85°	65%	72%
90°	60%	69%
95°	55%	66%

As spinning rooms frequently reach ninety degrees to ninety-five degrees Fahrenheit in summer, it will be observed that it is impossible to maintain a uniform regain and maintain a high efficiency of the operative unless a cooling system is used to keep the temperature down to about eighty-five degrees Fahrenheit. Silk spun under an atmospheric condition that maintains a regain of from eleven to eleven and one-half per cent shows a decrease in breaks of from ten to thirty per cent and a proportionate saving in waste and labor cost. These breaks vary according to the grade of silk spun. Chinas and hard nature Japans of the lower grades show the greater gains by use of humidity.

Prof. C. E. F. Winslow says it is quite clear that the principal thing that makes the air of confined spaces harmful, aside from the special problem of dust and fumes, is overheating, especially when combined with excessive moisture.

Elaborate psychological tests of color naming, naming opposites, addition, cancellation, mental multiplication, typewriting and grading specimens of hand writing, rhymed couplets and prose compositions, all failed entirely to show any effect of even the severe, eighty-six degrees—eighty per cent. relative humidity, condition upon the power to do mental work under the pressure of a maximal efficiency test. Option tests of the inclination to do work, in which the subjects had the choice of doing mental multiplication or typewriting for pay, or of reading novels or doing nothing, showed a distinct lessening in the total amount of work done in the hot room (eighty-six degrees—eighty per cent relative humidity), while with male subjects whose votes as to comfort showed no preference for the sixty-eight degrees over the seventy-five degrees—fifty degrees relative humidity condition, there was as much accomplished in the warm as in the cool room.

The results with physical work (lifting dumb-bells and riding a stationary bicycle) were much more definite. Again maximum effort tests showed no appreciable influence of room temperature, but when the subjects had a choice they accomplished fifteen per cent less work at seventy-five degrees, and thirty-seven per cent less at eighty-six than at sixty-eight degrees. These conclusions are quite what one would expect. Under pressure efficient work can usually be accomplished even under unfavorable conditions, but as a matter of common experience we find that the children in overheated schoolrooms and the workers in overheated factories are listless and inactive.

Experiments are now under way in regard to the influence of overheated rooms upon susceptibility to respiratory disease which promise to confirm the observations of Leonard Hill as to the changes in the mucous membranes which follow exposure to hot and dry air, while we find that the resistance of animals to artificial infection is very definitely lowered by chill following exposure to a hot atmosphere.

Frederick S. Lee found on experiments with animals that the distaste for physical labor which is felt on a hot, humid day, has a deeper basis than mere inclination; the muscles themselves are actually incapable of performing as much work.

Mr. Huntington made a careful study of the output of industrial workers in various factories in the state of Connecticut, as determined by their monthly wages for piece work, over a period of four years. He found that the annual course of production was as follows: low at the beginning of the calendar year, it fell still lower and reached its minimum at about the end of January; through the spring there was a gradual increase in output until June; then a moderate decrease until the end of July; in the autumn an increase to the maximum in November; and then the winter descent to the succeeding January minimum. Production was thus greatest in the spring and the autumn, and least in the winter and the summer. A very similar course was followed by the workers engaged in making electrical apparatus in Pittsburgh; and similar confirmation of the validity of the conclusions, with changes in details, was made by the output of other industrial workers in the southern states and by strength-tests of school children in Denmark. All these data combine to demonstrate that the greatest physical efficiency of the individual is found not during the summer or the winter, but at intermediate seasons.

In a document issued by the Government of the U. S. Proceedings of the Convention of Weather Bureau Offices (1898) appears an article by Dr. W. M. Wilson, of the Weather Bureau, entitled "Atmospheric Moisture and Artificial Heating." Among other things and after stating that the average normal humidity of winter air is about seventy-two per cent, Dr. Wilson proceeds as follows:

"For the purpose of obtaining data upon which to base a comparison between the average external humidity and the prevailing conditions with respect to moisture found in business offices and living rooms, observations were carried on during the past winter in buildings heated by steam, hot water, and hot air, and it was found that the average relative humidity from steam and hot water heating, with an average air temperature of seventy-two degrees, was twenty-eight per cent, while from furnace heating it was as low as twenty-four per cent. Dr. Albert Barnes, of Boston, found that the relative humidity in his office building, with an air temperature of seventy-two degrees, was thirty-one per cent, while Mr. Henry, in investigating the relative humidity in the Weather Bureau building at Washington, during March, 1896, found that with an air temperature of seventy-two degrees, the relative humidity was thirty-two per cent. From these observations it is safe to assume that the average relative humidity in dwellings and offices during that period of the year which requires artificial heating is about thirty per cent, or about forty-two per cent less than the average outside humidity, and drier than the driest climate known.

"The evaporation power of the air at a relative humidity of thiry per cent is very great, and when the tissues and delicate membranes of the respiratory tract are subjected to this drying process, a corresponding increase of work is placed upon the mucous glands in order to keep the membranes in proper physiological condition, so that nature, in her effort to compensate for the lack of moisture in the air is obliged to increase the functional activity of the glands; and this increase of activity and the frequent unnatural stimulation, induced by the changing conditions of humidity from the moisture laden air

outside to the arid atmosphere within our dwellings, finally results in an enlargement of the gland tissues, on the same principle that constant exercise increased the size of any part of the animal organism. Not only do the glands become enlarged, but the membrane itself becomes thickened and harsh, and sooner or later the surface is prepared for the reception of the germs of disease, which tend to develop under exposure to the constantly changing percentage of humidity.

"If the limitations of this paper allowed, it might be interesting to notice some remarkable cases which have come under observation where catarrhal troubles have been relieved and apparently cured by simply introducing sufficient moisture into the air to bring the conditions to something near normal."

Dr. F. G. Haworth, health officer at Darwen, England, writing in the Textile World Record, March, 1907, says: "In my opinion the introduction of moisture into the air in weaving sheds by artificial means is calculated to benefit the workers provided the relative humidity is kept within reasonable limits of the outside air; that its action on suspended particles, whether dust or microbes, is beneficial; that the workers therein are not more susceptible to such diseases as pneumonia, bronchitis, consumption, or rheumatism than other people, in which opinion statistics bear me out."

The author's observations show that the temperature in spinning rooms rises during the most extreme hot weather to one hundred and five degrees F., with a relative humidity of about forty-five to fifty per cent. The most extreme dry condition in winter time I found to be thirty-six per cent relative humidity.

Operatives working in mills having no humidification are susceptible to dry catarrh, as it is known in mill usage, which is remedied when the rooms are humidified. This is principally found among the operatives who have worked in the mill a number of years, and who remain indoors after working hours.

I have also observed that when the relative humidity is maintained at seventy-seven to eighty per cent at a temperature of seventy-five degrees F., the employees become chilly on going into the cool outside air and are more suspectible to colds and catarrhal troubles. That with an air change every ten minutes, spinners are uncomfortable at less than seventy-five degrees F. on account of the draft. I have further observed that a high efficiency of operatives can be maintained at the following temperatures:

70 to 75° F.	at	75 to 70°	relative humidity.
75 to 80° F.		70 to 68°	" "
80 to 85° F.		68 to 65°	" "

That the employees become listless and inactive when the temperature rises above eighty-five degrees F. and seventy-two per cent relative humidity.

William O. Hartshorne, Consulting Engineer of Methuen, Mass., says in a pamphlet presented at an annual meeting of the American Society of Mechanical Engineers, that with materials as valuable as silk, wool, flax and cotton and such of their products as are sold by weight, the actual weighing of the moisture they may happen to contain at the time of sale is of evident importance to both buyer and seller. He has, after an investigation covering

a period of over twenty years, developed a set of laws governing cotton and worsted, which are set forth in the paper with particulars regarding their derivation, and are accompanied by numerous charts and tables for facilitating calculations. He states that the most significant effect of moisture contents upon textiles may be classified under these general heads:—I. Weight.—II. Dimensions.—III. Strength and Elasticity.

It is to be regretted that Mr. Hartshorne has confined his experiments principally to cotton and worsted and those interested in the subject may obtain further details by addressing themselves to Mr. Hartshorne.

The precipitation of moisture on the outside of windows and the sweating on the inside during cold weather causes the rotting of the sash and the falling out of putty, which must be replaced every two or three years.

Walls should be made hollow and roofing extra thick to avoid cold walls and ceiling of roof. If these precautions are not taken then during cold weather the walls sweat and the moisture causes the mortar to crumble, requiring occasional refacing. The ceiling of the roof also rots and requires replacing, or at least patching up every ten to fifteen years.

Humidity causes cotton bands to contract and leather belts to expand, just the reverse of the cotton bands.

On belt spinners the twist is increased about four per cent and the power increased in the same proportion, due to the belt being more pliable and drawing better.

Bobbin heads are prevented from becoming loose, due to excessive drying out in winter time.

Kinks in first time twist are less and easier to rub out before starting up in the morning.

The threads are less wiry and do not swing over into the next bobbin and break down the thread.

Guide eyes, tension, wires, etc., are more or less slippery, due to the moisture, and their life is prolonged about fifty per cent. This is also aided by the soft and pliable thread brought about by humidity. The thread can also be set better on hard twist when spun under humid conditions.

Conclusions

It will be observed that by adding humidity to a hot spinning room, we decrease the breaks by making the thread ductile and pliable, but it decreases the efficiency of the operatives when the humidity is maintained too high. Where it is desired to return Japan silk with the moisture contents at which the silk is bought, two per cent plus conditioning weight or a regain of thirteen per cent, it will be observed that there are times when the humidity must be kept too high at existing temperature to be comfortable or healthful for spinners. This is a very strong argument in favor of adopting the conditioning weight as the basis of billing.

Second. That there are limits within which humidity will show efficient spinning results when it is maintained at a per cent which causes employees

to become listless and inactive, then even though the breaks are decreased, the net efficiency may be lower than without humidity.

Third. That to maintain a uniform regain and highest efficiency in spinning it becomes absolutely necessary to have a cooling system in connection with humidification.

Fourth. That, as far as moisture absorption is concerned, it is the final process that really counts. The spinning room, therefore, need not be kept at a higher humidity than is necessary to give maximum spinning results and the regain can be secured in reeling or redrawing department. Time, however, must be allowed for the lagging effort of the silk, which is largely governed by how tight the silk is wrapped on shaft or bobbin. The lagging effect, or in other words the time it takes silk to absorb the desired moisture, is also governed by how dry the silk was before entering the humid room; to humidify only the reeling department, and not the spinning, will not give the same results in the same time as when the spinning department also is humidified.

APPENDIX—PART IV

TESTING METHODS IN USE AT THE UNITED STATES TESTING CO., INC., THE OFFICIAL TESTING HOUSE OF THE SILK ASSOCIATION OF AMERICA THE TESTING OF RAW SILKS

As conducted by the United States Testing Co., Inc.
By D. E. Douty in SILK.

Tests for Moisture.

The most extensively applied test at present is the test for moisture. The operation is called **conditioning** and the institutions whose function it is to determine moisture and make other tests are called **Conditioning** or Testing Houses.

The test is made by taking a bale of raw silk or five bundles of thrown silk, removing all of the tare (rope, string, paper, etc.), which is weighed, and determining the net weight of the silk. At the very time the net weight is determined sample skeins are drawn from different portions of the bale or bundles so as to represent the condition in all parts. These skeins are weighed at once. They are then placed in an especially constructed drying apparatus called a conditioning oven maintained at a temperature considerably above the temperature at which water boils or becomes steam. In this way all of the water contained in the silk becomes vapor and is carried away by a stream of hot air which constantly flows through the silk.

The silk weighs less as it loses the water and when all the water is dried out the weight becomes constant, that is, loses no more. The weight of the absolutely dry silk is called its **absolute weight.** By international agreement, the absolute dry weight plus eleven per cent is called **the conditioned weight.**

The eleven per cent is the agreed amount of allowable moisture and is called the standard regain (French—reprise, Italian—represa, German—Zusatz).

Fig. 1 is an exact reproduction of a certificate, with fictitious names and number inserted, for conditioned weight, issued by the United States Testing Company, Inc., for a bale of Japan raw silk. The values are expressed in kilograms (Ko.), grams, pounds and decimals of a pound.

The first figures, Ko. 59.20 is the shirt weight, that is, the weight of the bale with the rush covers removed, determined by the Testing Company.

The "shirt and rope" weighed Ko. 0.31 and the "paper and string" on the books weighed Ko. 0.99, making a total tare of Ko. 1.30. Therefore the net weight was Ko. 57.90 which is equal to 127.65 lbs.

Eighteen skeins were drawn from the bale at the same time the net weight was determined. These were divided into three sets of six skeins each and carefully weighed. Two sets were then dried independently as described above, the third being held in reserve to be used if the other two did not agree with one another. The two sets agreed and were therefore combined to compute the value.

The twelve skeins (two sets) weighed originally (i. e. at the moment of drawing from the bale), grams 778.60; after they were completely dry their absolute weight was 689.70 grams.

To compute the absolute weight of the bale from these results becomes a matter of simple proportion expressed as follows:

The net weight of the sample is to the net weight of the bale, as the absolute weight of the sample is to the absolute weight of the bale.

Putting this statement into a formula we have:

Net Wt. sample: Net Wt. Bale=Abs. Wt. sample: Abs. Wt. Bale; or

Net Wt. sample $\times$ Abs. Wt. Bale = Abs. Wt. Sample $\times$ net wt. bale.

Then:

$$\text{Abs. Wt. Bale} = \frac{\text{Abs. Wt. sample} \times \text{net wt. bale}}{\text{net wt. sample}}$$

Putting in the values on the certificate we get:

$$\text{Abs. Wt. Bale} = \frac{689.70 \times 57.90}{778.60} = \text{Ko. } 5129$$

Adding to the Abs. Wt. of bale eleven per cent which equals Ko. 5.64, the conditioned weight is Ko. 56.93 = 125.61 lbs.

The consignor and consignee each day pay one-half the charges and there is no possibility of dispute regarding the amount of the invoice as the certificate of the Testing House, according to the Regulations of the Silk Association of America, is final.

Test for Boil-Off.

The degumming or boil-off test as it is called in America stands next to the moisture test in the extent to which it is applied in the American silk industry. Notwithstanding the fact that the gum in Japan raw varies from sixteen per cent to twenty four per cent; Italian, nineteen per cent to twenty-five per cent; China, sixteen to twenty-three per cent; Canton, eighteen to twenty-four per cent, and Tussah, nine per cent to twenty-seven per cent, the sales contracts for raw silk in the New York market contain no clause regarding the amount of gum agreed to as the basis of price.

The amount of useful fibre contained in a bale of silk depends upon its amount of clean dry fibre. The amount of clean dry fibre per hundred pounds of dry, raw silk based upon the Testing House Statistics for 1914 will be, in the case of Japans, seventy-six pounds to eighty-four pounds; average for the year, 81.15 pounds.

Italians,	75 lbs. to 81 lbs.,	average for year,	77.35 lbs.
Chinas,	77 lbs. to 84 lbs.,	average for year,	81.35 lbs.
Cantons,	76 lbs. to 82 lbs.,	average for year,	77.66 lbs.
Tussah,	73 lbs. to 91 lbs.,	average for year,	87.23 lbs.

The more frequent variations are four per cent. for Japan, Italian and Chinas; silks may have is approximately as follows: Japan, eight per cent; Italians and Cantons, six per cent; Chinas, seven per cent; Tussahs, eighteen per cent.

The more frequent variations are four per cent for Japan, Italian and Chinas; five per cent for Cantons and fifteen per cent for Tussahs.

Since these variations in the amount of useful fibre contained in raw silk are not recognized in the sale of raw silk in the New York market the question might properly be asked: What use are boil-off tests on raw silk?

They are very important, for the reason that an accurate clearance cannot be computed for a lot of thrown silk unless conditioning and boil-off tests have been made in sufficient number on the raw.

It is absolutely necessary to know the amount of moisture and percentage of gum sent to the throwster in the raw silk, and the amount of moisture and the percentage of gum, soap and oil returned by the throwster in the thrown to determine accurately the amount of waste that has been made and the amount of dry, clean and, therefore, useful fibre returned by him.

Fig. 2 is a reproduction, with fictitious names and number inserted, of an actual boil-off certificate upon one bale of Japan raw. Ten skeins were drawn from the bale, one from each of ten different books, representing all portions. From each of these ten skeins a small portion is parted sufficient to make a combined weight of over 100 grams. This portion becomes the test sample. It is placed in the conditioning oven completely dried and its absolute weight determined. It is then submitted to the standard boil-off test used by all Conditioning or Testing Houses and again dried to absolute weight.

The difference between these two absolute weights represents the loss expressed in grams, and this loss can be expressed in percentage by dividing it by the absolute dry weight "before" and multiplying by 100. Using the figures in the certificate we have:

$$120.72 - 97.5 = 23.22$$

$$\frac{23.22}{120.72} \times 100 = 19.23\%$$

This shows that for this particular bale of Japan there were 80.77 lbs. conditioned weight clean fibre per 100 lbs. conditioned weight of raw silk.

A boil-off certificate for thrown silk would be expressed in the same manner and the test would be made in the same way.

Twist and Measuring.

The twist and measuring tests are applied to thrown silk. The twist shows the number of turns per meter and the uniformity of twisting. Ten specimens are carefully untwisted or opened by means of an apparatus called a twister and the number of turns is expressed in terms of one meter of length. The average is computed and expressed as the number of turns per inch.

Fig. 5 is a reproduction of a twist test. The first column gives the number of turns put in the thread and second column gives the number of turns in the spinning or folding of the threads into tram or organzine.

Fig. 6 is a reproduction of a measuring or length of skein test. Ten skeins selected from the lot are wound on to spools and re-reeled with uniform tension

United States Testing Co., Inc.

OFFICIAL TESTING HOUSE FOR

The Silk Association of America

Certificate for Conditioned Weight

No. A 4 C. TRIPLICATE

NEW YORK.

Messrs. John Doe & Co.,

James Smith & Bros.,

MARK AND NUMBER

A.L.

ONE BALE Japan Raw,

GROSS WEIGHT		KG.	
	SHIRT WEIGHT	"	59.20
TARE	SHIRT AND ROPE 0.31 / PAPER AND STRINGS 0.99	"	1.30
NET WEIGHT LBS. 127.65		KG.	57.90

OF 18 SKEINS DRAWN FOR TEST

12 WERE USED, WHICH WEIGHED

ORIGINALLY GRAMS 778.60

WHEN REDUCED TO ABSOLUTE WEIGHT " 689.70

ABSOLUTE WEIGHT OF ENTIRE BALE

CALCULATED FROM ABOVE WEIGHTS KG. 51.29

ESTABLISHED REGAIN FOR MOISTURE, 11% " 5.64

CONDITIONED WEIGHT LBS. 125.61 KG. 56.93

CHARGES TO CONSIGNOR $ 0.75

CHARGES TO CONSIGNEE $ 0.75

SIGNED FOR THE COMPANY D E Douty

Laboratories: 340-344 Hudson Street, New York.

Telephone 8751 / 8752 Spring

Fig. 1

United States Testing Co., Inc.

OFFICIAL TESTING HOUSE FOR

The Silk Association of America

Certificate for Boiling Off

No. B 3 B. ORIGINAL

NEW YORK.

Messrs. John Doe & Co.,

MARK AND NUMBER

A.L.

1 Bale Japan Raw,

SAMPLE TAKEN FROM 10 SKEINS

NET WEIGHT GRAMS

No.	NET WEIGHT	ABSOLUTE WEIGHT BEFORE	ABSOLUTE WEIGHT AFTER	LOSS	%
1		120.72	97.5	23.22	19.23
2					
3					
4					
TOTAL					
5					
TOTAL BEFORE					
" AFTER					
LOSS				EQUALS	

CHARGES $ 1.00

SIGNED FOR THE COMPANY D E Douty

Laboratories: 340-344 Hudson Street, New York.

Telephone 8751 / 8752 Spring

Fig. 2

upon a special measuring reel with a counter indicating each revolution of the fly. From the total length and total weight of the skeins, without regard to the moisture they contain, the average dramage is computed. This should not be confused with the dramage obtained by a regular sizing test, because it is only a rough value which indicates in a general way the yardage of the silk. The result

United States Testing Co., Inc.
OFFICIAL TESTING HOUSE FOR
The Silk Association of America.

Certificate for Size, Twist, Elasticity & Tenacity

No. B 12 A.

New York, ______ 191

Certificate for Messrs. John Doe & Co.,

A.L.

for Test made on sample of Japan Raw, 10 skeins.

SIZING			TESTS MADE ON ONE METRE LENGTH: FIRST TWIST	SECOND TWIST	ELASTICITY	TENACITY
11	13	14½				
11½	13½	14½				
12	13½	14½				
12½	13½	14½				
12½	13½	15				
13	13½	15				
13	14	15				
13	14	15½				
13	14	16½				
13	14	16½				

Total Addition 412.5
Total Weight 412.0
Average Size on Actual Weight 13.73
Average Size on Condition Weight
Average Number of Thousand Yards per Pound 324½

Average:
First Twist, Turns per inch
Second Twist, Turns per inch
Elasticity
Tenacity

Signed for the Company,
D E Douty

Charges, $ 1.00

N.B.: The samples are 450 metres long, weighed in half Decigrams. The average size is calculated on the total weight taken before the partial weights.

Elasticity in Millimetres. Tenacity in Grams.

Laboratories: 340 to 344 Hudson Street, New York.
Telephone Connection.

Fig. 3

United States Testing Co., Inc.
OFFICIAL TESTING HOUSE FOR
The Silk Association of America.

Certificate for Size, Twist, Elasticity & Tenacity

No. B 9 B.

New York, ______ 191

Certificate for Messrs. John Doe & Co.,

A.L.

for Test made on sample of Japan Raw, 10 skeins.

SIZING			TESTS MADE ON ONE METRE LENGTH: FIRST TWIST	SECOND TWIST	ELASTICITY	TENACITY
					202	64
					208	52
					218	55
					212	64
					210	62
					212	64
					206	55
					218	55
					220	59
					230	60

Total Addition
Total Weight
Average Size on Actual Weight
Average Size on Condition Weight
Average Number of Thousand Yards per Pound

Average:
First Twist, Turns per inch
Second Twist, Turns per inch
Elasticity 213.6
Tenacity 59.0

Signed for the Company,
D E Douty

Charges, $ 0.75

N.B.: The samples are 450 metres long, weighed in half Decigrams. The average size is calculated on the total weight taken before the partial weights.

Elasticity in Millimetres. Tenacity in Grams.

Laboratories: 340 to 344 Hudson Street, New York.
Telephone Connection.

Fig. 4

of the measuring test should never be used as a basis of computing clearances. They are not intended for that purpose and are not sufficiently accurate. They serve principally as a check on the uniformity of reeling and as an assistance in the computing of warp ends from a given lot.

United States Testing Co., Inc.

OFFICIAL TESTING HOUSE FOR

The Silk Association of America.

Certificate for Size, Twist, Elasticity & Tenacity

No. B 7 C.

New York, ____________ 191

Certificate for Messrs. John Doe & Co.,

A.L.

for Test made on sample of Japan Organ, 10 Skeins

SIZING			Tests made on One Metre Length — First Twist	Second Twist	Elasticity	Tenacity
			592	478		
			636	506		
			608	424		
			642	488		
			646	536		
			628	540		
			576	522		
			650	514		
			614	506		
			602	560		

	Average
Total Addition	First Twist, 15.48 Turns per inch
Total Weight	Second Twist, 12.68 Turns per inch
Average Size on Actual Weight	Elasticity
Average Size on Condition Weight	Tenacity
Average Number of Thousand Yards per Pound	Signed for the Company, D. E. Douty

Charges, $ 0.75

N.B.: The samples are 450 metres long, weighed in half Decigrams. The average size is calculated on the total weight taken before the partial weights.

Elasticity in Millimetres. Tenacity in Grams.

Laboratories: 340 to 344 Hudson Street, New York.

Telephone Connection.

Fig. 5

United States Testing Co., Inc.

OFFICIAL TESTING HOUSE FOR

The Silk Association of America.

Certificate of Length of Skeins

No C6 B. DUPLICATE

NEW YORK ____________

Messrs. John Doe & Co.,

TEST MADE ON Japan Organ, 2 Thrd, 10 SKEINS

MARK AND NUMBER				
A.L.	1	19831 YDS.	11	YDS.
	2	19852 "	12	"
	3	19721 "	13	"
	4	19768 "	14	"
	5	19968 "	15	"
	6	19709 "	16	"
	7	19855 "	17	"
	8	19872 "	18	"
	9	19738 "	19	"
	10	19843 "	20	"

TOTAL 198,157

AVERAGE 19,816 YDS

AVERAGE DRAMAGE: 1.78 DRAMS PER 1000 YDS

CHARGES $ 1.00

SIGNED FOR THE COMPANY ____________

Laboratories: 340-344 Hudson Street, New York.

Telephone 8751 8752 Spring

Fig. 6

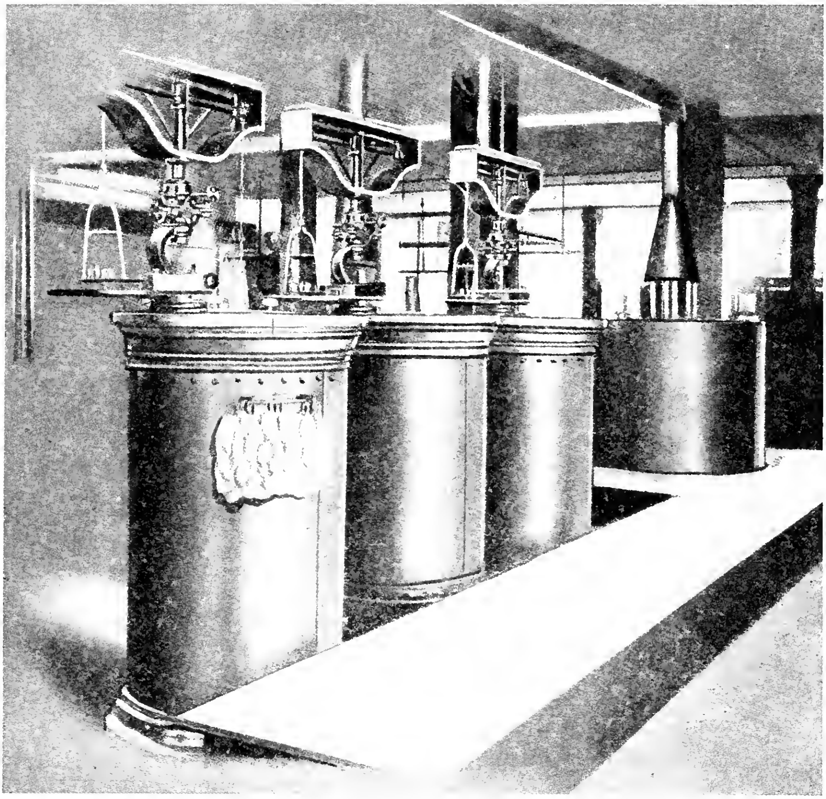


Fig. 82

EVENNESS AND CLEANNESS

W. F. Edwards

Director of Research, United States Testing Co., Inc. in SILK.

The mechanical fitness of raw silk for manufacturing purposes depends, for the most part, on the uniformity of the cross section of the thread. If the thread is considered as a body having a circular cross section, then the mechanical fitness depends on the uniformity of its diameter. As a matter of fact, the cross section is of somewhat variable shape, but for the most of the purposes of these notes I shall assume that the thread has an approximately circular cross section.

The mechanical fitness of raw silk is now usually considered in two categories, under the names evenness and cleanness. Evenness embraces those cases of irregularity of cross section usually shown by long stretches of the thread being smaller or greater than the average cross section. Cleanness embraces those cases of irregularity in the cross section that are limited usually to short stretches of the thread and generally do not show as solid compact portions, but rather as excrescences or looped or split portions of the thread and are commonly much more numerous than the evenness defects.

For practical purposes the evenness defects have been segregated into four divisions: (1) weak threads (breaking between thirty per cent and fifty per cent below the average strength of the thread); (2) very weak threads (breaking more than fifty per cent below the average strength of the thread); (3) coarse threads (breaking between thirty per cent and fifty per cent above the average strength of the thread); and (4) very coarse threads (breaking more than fifty per cent above the average strength of the thread).

Cleanness defects have been segregated for a like purpose into two groups with five divisions in each group. The first group embraces what are considered to be major (more harmful) defects and are called: (1) waste, (2) slugs, (3) bad casts, (4) split threads and (5) very long knots. The second group includes what are considered to be minor (less harmful) defects and are called: (1) long knots, (2) corkscrews, (3) loops, (4) nibs, and (5) raw knots.

In a general way the evenness defects are considered by manufacturers as much more serious than major cleanness defects, notwithstanding that the latter are usually much more numerous. Likewise, major cleanness defects are considered as much more serious than minor cleanness defects, though the latter are usually comparatively much more numerous.

Much work has been done in attempts to establish a relative manufacturing value in silks by comparing the evenness and cleanness defects as determined by mechanical tests in order to have values based on numerical data rather than sight and touch inspections, at the same time recognizing the value of such inspections when made by competent inspectors. It is only fair, I think, to state that no entirely satisfactory results have come from these attempts. However, they have opened up a hopeful outlook for the mechanical testing of silk as a means of grading it for manufacturing purposes.

What is needed very much, in the writer's judgment, is a more determinate description of raw silk than is given by such names as Crack Double Extra or Best No. 1, or ninety-four or seventy-six per cent, or any other all-embracing terms. A description based on mechanical and physical properties seems to be the most hopeful and can be of great value whenever the mechanical and physical properties can be determined by tests with a fairly high degree of certainty; i. e., so that a duplicate series of tests on the same silk will check close enough for practical use.

It is my purpose in these notes to call attention to some of the more important mechanical tests that have been tried for the purpose of grading silk by defects and to call attention to some of what seem to me to be their strong and weak points, hoping thereby to make more clear the value of the tests and to indicate some of the difficulties encountered in carrying them out. I shall in doing this pass over attempts at micrometric and caliper measurements for this purpose as practically futile, though theoretically they are quite appealing, and take up in order the sizing test, the serimeter test, the mirror tests and the gage test.

Sizing Tests

The primary purpose of the sizing test is to convert weight into an equivalent in length or "yardage" and it is done in a way to make possible the discovery of variations due to lack of care on the part of the reeling girl in keeping the proper relation between the beginning, middle and end portions of the cocoon baves running together to make up the silk thread.

The regular standard sizing test consists in weighing and comparing the weights of thirty skeins, 450 meters long, taken three consecutively from each of ten sample skeins taken at random from a bale, no two from the same book. Each three skeins represent 1350 meters of silk from a single skein and the thirty sizing skeins represent in all 13,500 meters of silk thread.

The weight of these skeins usually varies even among those taken from the same sample skein and sometimes shows quite wide limits between the lightest and heaviest of the thirty skeins. For this reason the variation in the sizing skeins has come to have for many users of silk significance as an indication of evenness as described in the foregoing four divisions.

In order to use the sizing skeins to advantage for this purpose, it is best to arrange their weights in some orderly way on the report sheet so that one may at a glance get a good general survey of the variations and the extremes for those taken from the same sample skein as well as for the whole of the thirty skeins. * * *

All tests tend to suggest that for the same amount of silk one can get a better idea of evenness by increasing the number of skeins, but there has not been any adequate data accumulated for comparisons to determine what increase in the number of skeins would give a consistent and repeatable evenness for a silk. More data collected from different sources with the mill run proofs of the adequacy of the tests are necessary before offering any definite opinion.

The usual argument against the adequacy of variation in sizing skeins as an indication of evenness is that fine and coarse threads of considerable lengths may be present in the same skein and balance each other, not, therefore, showing in the weight of the skeins. If the length of sizing skeins were made about one hundred meters and they were weighed with a high degree of accuracy, a very good idea of evenness from these skeins could possibly be obtained, though there would still be chance enough for the balance of fine and coarse threads.

Suppose that a fine thread (thirty per cent undersize) in order to be considered a serious defect must be fifty meters long; i. e., one-ninth (1/9), the length of the sizing skein. One would then have a weight that was to the average weight as $400+\frac{50x7}{10}$ is to 450. The skein would, therefore, weigh $\frac{435 x 14}{450}$ = thirteen and five-tenths deniers in case the average size was fourteen deniers. This shows that a deviation of five-tenths denier below the average weight would indicate a fine thread fifty meters long. A greater deviation would indicate a longer or finer weak thread in proportion to the deviation. * * *

The 225-meter skeins are twice as many in number and indicate roughly twice as many fine and coarse threads as are indicated by the 450-meter skeins. If, likewise, we were to make skeins 112.5 meters long, we would have 120 skeins, and if we weighed them to the nearest half denier we would doubtless increase the number of indications of fine and coarse threads and decrease the chance of fine and coarse threads balancing one another within the skeins, but furnish no conclusive proof.

Cutting down the length of the skein is useless unless we weigh with a higher degree of accuracy. Cutting the length of the skeins to 112.5 meters and weighing to a tenth denier might furnish a much better indication of the evenness, just as weighing to one-quarter denier is considered better in case of the 225-meter skeins than one-half denier in the case of the 450-meter skein.

Applying the same reasoning to the larger sizes we find that a variation of about seven-tenths denier over or under size indicates a fifty-meter length of thirty per cent undersize or oversize as the case may be, for the average size of twenty-one deniers. Also, that a variation of about one denier represents the like oversize and undersize for an average size of twenty-eight deniers.

This use of sizing skeins as an indication of evenness requires much more accumulation of data for comparison. The data should include 450, 225 and 112.5 meter sizing tests made with a high degree of accuracy and should be compared with data obtained by the tests described below. All should be checked by mill run sheets. (More publicity is needed in this latter respect for best results.)

The Serimeter Test

The serimeter shown in Figure 83 is one of the latest and best types. It is designed to apply tensile stress to a silk thread so as to give an approximately uniform rate of strength. This is accomplished by attaching the lower clamp,

C, to the piston rod of a piston working in oil and falling by its own weight. The usual speed of this piston is eighty c/m per minute when pulling on a silk thread one-half meter long. The stress is read on the circular scale S, and the elongation on the vertical scale K. A is an attachment devised in the shop of the United States Testing Company, Inc., to make possible the use of other lengths of the silk thread than the half meter for which the apparatus is constructed. The apparatus automatically registers the breaking strength and the stretch at breaking stress.

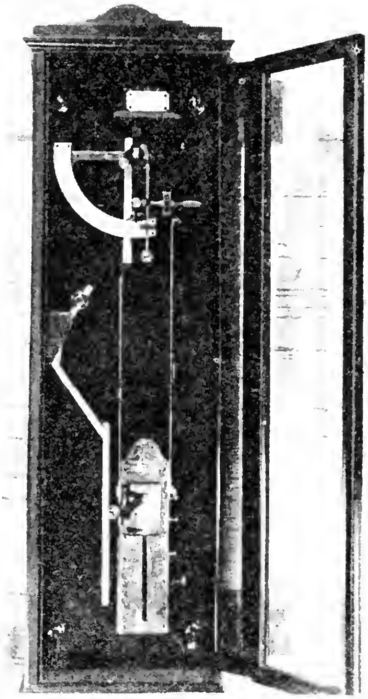


Fig. 83

The serimeter test of ten breaks is usually reported so as to give the breaking strength and the elongation at rupture for each and the average of the ten. Table 6 gives three examples from actual tests, made in the laboratory. In these tests painstaking choice of the portions broken insures that these portions are as good representative specimens as can be chosen by the eye. It will be noticed that even in the most uniform set, No. 1, there is a considerable variation amounting to as much as twenty-five per cent of the average, a variation that would not be admissible in the case of steel.

When one considers carefully the makeup of the silk thread he is not surprised at these variations, but is rather surprised that they have been used to such an extent for determining the physlcal quality of the silk. The thread is made up of cocoon threads, which themselves are of variable cross section and which can be made variable in their nature by the processes in the filature. Then, the cocoon baves making up the raw silk thread may be of different lengths in the same portion of the silk thread, due to a sort of waviness in one and straight lay of another.

Altogether it is easy to see that a larger number of breaks than ten is necessary to get anything like a good average result that can be closely repeated on a check test. Moreover, these tests at best only give the breaking stress and elongation at rupture and do not give the characteristic stress-strain relations for stresses below the breaking stress.

No. 1		No. 2		No. 3	
Elasticity	Tenacity	Elasticity	Tenacity	Elasticity	Tenacity
202	75	196	48	157	54
165	64	240	75	205	73
180	55	161	62	229	69
205	62	171	43	143	58
222	54	181	60	164	55
204	60	217	49	178	78
190	64	190	64	202	64
196	50	185	67	162	48
190	64	210	63	143	56
168	64	204	40	184	56

Table 6

The variation in the breaking strength (tenacity) of the raw silk thread as found by the serimeter has received considerable attention as an indication of the evenness of the silk thread. This test when made on only ten portions as a quality test is of very doubtful value as an indication of evenness. However, if the number of portions is made large enough and the portions are chosen with good judgment, the variation in the breaking strength of these several positions may give a very good idea of the "run" of the silk thread.

The portions of threads to be broken may be chosen to advantage from the thirty or sixty sizing skeins formed in making the sizing test. These skeins should be cut once across, giving 112.5 centimeter lengths, 12,000 portions and 13,500 meters of length. The portions chosen should be taken at random from the sizing skein, but should be taken in equal number from each and every skein. This will give a good distribution of the portions throughout the 13,500 meters of silk. Ten portions taken at random from each of the thirty or five from each of the sixty (the latter preferred), three hundred in all, will make a very good test for this purpose.

As a probability speculation, we might assume that in the 13,500 meters of silk in the sizing skeins there are known to be two forty-five meter portions that are weak (thirty per cent under average); what is the probability that both are in the sample skein or one in the first sample skein and the other in the tenth or some other sample skein; or what probability that the whole of the forty-five meters is in a single sizing skein rather than distributed in two? It is easy to see that such speculation does not lead us along the road of assurance; each case is only that of the usual white and black ball illustration of our text books in algebra.

However, if we take the thirty sizing skeins of the 450 meter sizing test, and assume that the whole forty-five meter weak portion is in a single skein and that there are two such weak portions there, the probability of drawing a skein at random from the thirty is one-fifteenth, since there are two favorable and twenty-eight unfavorable opportunities in a total of thirty, something more definite. But better still, if we choose one 112.5 centimeter portion at random from each of the thirty sizing skeins, thirty portions in all, we have a higher probability of "catching" the weak thread in thirty breaks than is given above of catching it in the first skein drawn, since two forty-five meter weak threads make eighty of the 12,000 portions made by cutting once across the sizing skeins. The first portion drawn, therefore, has a favorable chance of only one one-hundred-and-fiftieth (1/150) as against one-fifteenth in the case of drawing the skein, but when thirty are taken, one from each skein, the probability becomes approximately 30/150, or one-fifth which is three times as favorable as drawing the skein. Now if we draw two at random from each skein the probability becomes roughly 60/150 and so on until we draw five portions from each skein, when it becomes practically certain that one of the 150 will be weak, and so on until ten are taken from each sizing skein, making 300 in all, when it is practically certain that we should find two weak portions indicating the two weak threads.

It will be seen that if the two weak threads had been each nine instead of forty-five meters long the probability of "catching" them in the 300 breaks would not have been as great. In like manner one can reason that had the two weak portions been ninety meters each the probability of catching them in 300 breaks would be greater than when they were only forty-five meters long. In general the longer the weak portion or the more numerous the short weak portions the more probability of "catching" at least one of them in 300 breaks, and conversely.

It is obvious that the same reasoning can be applied in the case of probability of catching the coarse portions of the thread. The serimeter test, therefore, like the sizing skein range test, works equally well in discovering fine and coarse portions of the thread. Like the sizing skein range test, it is not sufficiently conclusive.

The Serigraph Tests

Fig. 84 shows a serigraph designed for giving recorded stress-strain relations of cocoon baves or single ray silk threads. It is a very ingenious device and in skilled hands can give very good results. Nevertheless the writer, recognizing the academic value of these tests, hopes that a simpler and more satisfactory apparatus may be devised for this purpose.

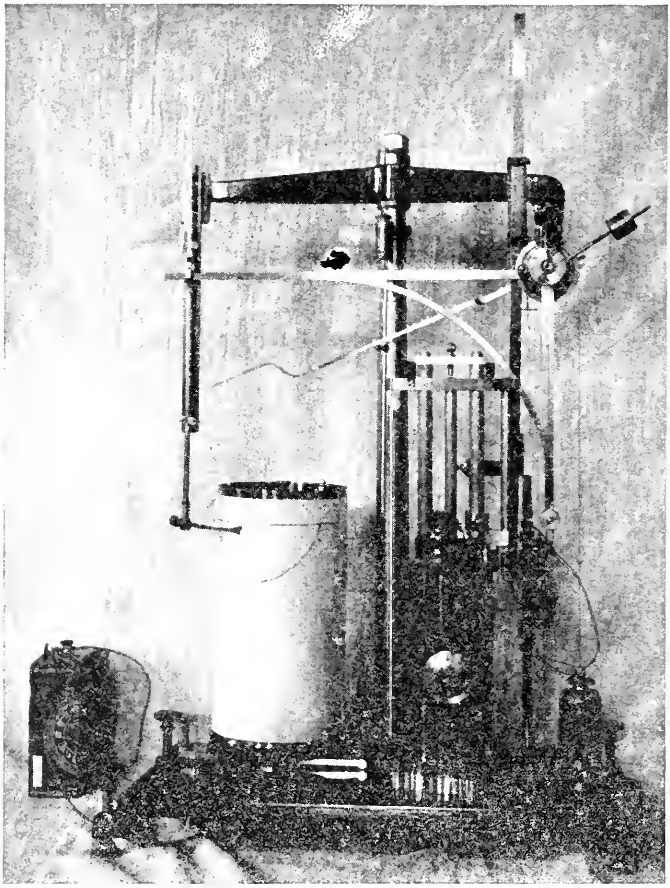


Fig. 84

This apparatus is described in sufficient detail in the March, 1920, number of SILK in the second monthly part of a paper running through several months on "A Study of the Physical Properties of Silk," by Dr. Hagihara, of the Kyoto Higher Technical School.

In describing this apparatus and the principles of its action, Dr. Hagihara has used one quite significant sentence which I shall quote for the purpose of emphasizing it. He writes: "It is more important for practical purposes to determine the behavior of the thread in the course of the loading than the breaking strength and elongation." I wish to emphasize particularly the phrase "for practical purposes," inasmuch as all too little consideration has been given to this subject.

The serimeter test as usually carried out, as already pointed out, does not record the breaking strength at rupture, but records the maximum load the thread will support before weakening. It records the elongation at rupture so that it does not furnish a single point of such a curve as that for soft steel. It shows the maximum stress and the maximum stretch, which are really two different points on the curve. What is needed is the points of stress-strain relation for each point of stress up to the maximum stress. In the hands of a careful skilled operator, Dr. Hagihara's serigraph gives this relation with a fair degree of accuracy. However, much more work should be done with it by different workers to check and confirm Dr. Hagihara's work and deductions. One of the greatest difficulties to be met is the lack of uniformity in cross section and composition, even in a single cocoon thread of short length.

In the case of silk, we have not gone far enough as yet to develop a suitable method of getting the stress-strain relation beyond the point of maximum stress up to and including the point of rupture. The important thing to note is that silk, like soft steel, does not rupture at maximum load, and shows a quite high degree of elasticity, ranging from about forty per cent to about sixty per cent of the maximum stress.

The serigraph shown in Figure 85 is a somewhat modified fabric testing machine, and is much more adapted to testing the elastic properties of silk for practical purposes than the serigraph shown in Figure 84. It is not suited to testing single threads, but is used with one hundred or more threads in parallel. The machine shown has a capacity suited to 200 or 400 threads in parallel.

The 200 threads may best be taken from a sizing skein of the 225-meter sizing test by simply cutting it once across, and the four hundred threads may be taken in like manner from the 450-meter sizing skein of the 450-meter sizing test.

The test is made on a length of ten centimeters (four inches), between jaws of the serigraph, and with the jaws separating at a uniform speed of six inches per minute.

Altogether the serigraph test on 200 or 400 raw silk threads in a bundle is a practical test, easily and quickly made, and shows the stress-strain relation up to the maximum stress, which is all that is required in practice.

Mirror Tests

The sizing skein weights and the serimeter breaks as described above clearly do not furnish the conclusive evidence on evenness that is desirable for practical purposes, to say nothing about the kind of accuracy that is required by the investigator. Moreover, these tests do not determine cleanness defects at all.

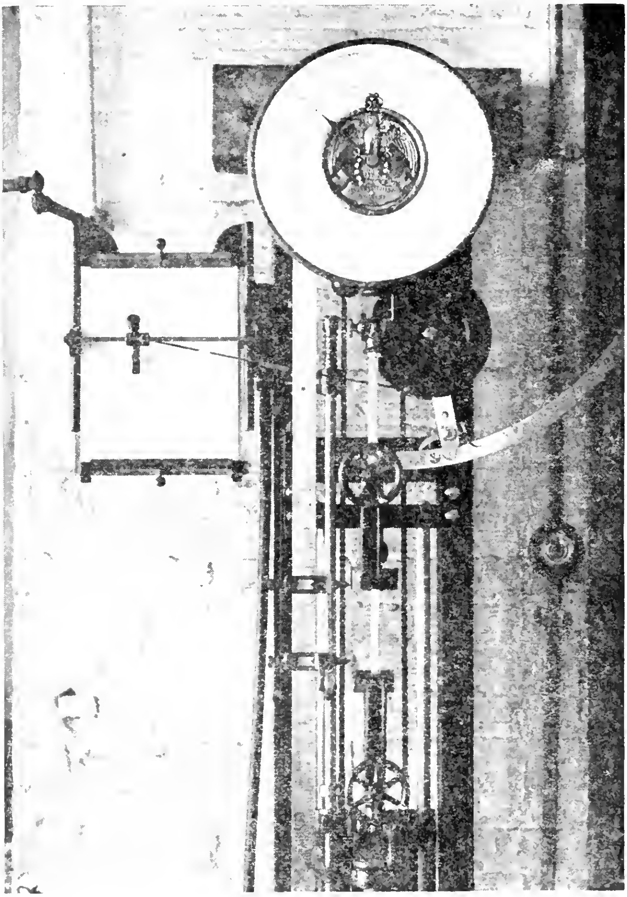


Fig 85

Mirror tests, as the black card inspection is called, have the merit of showing all of the silk under test so that defects of all kinds may be examined, but as usually carried out there is not enough silk shown to be representative

of the lot. For a quick "glance-over" inspection a large amount of silk is not as satisfactory on the whole as a smaller amount carefully selected. The eleven-inch by seven-inch inspection cards (size of cards so chosen because twenty-two-inch by twenty-eight-inch cardboard cuts without waste to this size) having, say, 250 meters of silk to the card, give a good enough quick survey of the raw silk. There should be ten cards, each one having silk from a single sample skein, the ten representing the ten sample skeins chosen from a bale in the standard way of sampling. These cards will at a glance to the experienced eye show whether the silk from the different skeins is apparently alike and whether it has many or few defects and whether the more harmful or less harmful defects predominate.

Careful attention should be given to one difference between mirror tests for thrown silk and spun silk yarns and mirror tests for raw silk. In the case of raw silk threads of nine (9) denier average size, we have an average diameter of about 0.0017 inch, one six-hundredth inch, very approximately. (For more details of the diameter of raw silk see below under Gage Test.) Students on the vision of the human eye tell us that it requires a "sharp" eye to see an object one six-hundredth inch in diameter, so that a nine denier raw silk thread is right at the limit of clear distinct definitive human visibility. An illustration of limit of visibility is furnished by spider web silk which is seen on a foggy morning after a dry spell of weather. During the dry weather the spiders are busy as usual making their snare webs, but these are invisible until condensed moisture on them shows them to us, giving an impression that they have sprung into existence over night.

Students of human eye visibility also tell us that the smallest visual angle under which two points may be recognized as two distinctly separate points is one minute of arc; at smaller angles the retinal images of the two points merge into one. At fifteen inches from the eye, a good reading distance for fine print, an angle of one minute subtends an arc of approximately .0045 inch in length, which is about two and one-half times the diameter of a nine denier raw silk thread. Silk threads should be placed on the mirror cards with at the least .0045 inch between them. From fifty to one hundred threads to the inch, according to the size of the thread, will be found better than a higher number.

It should be noticed that the first case has to do with the ability of the human eye to see a thing at all and that the second case has to do with its ability to separate things into distinct parts, each of which parts must be visible by itself, i. e., the parts must be at least one six-hundredth inch in smallest dimensions. To make this clear consider a black line ruled on white paper. Taking no account of iridescence, the line must be one six-hundredth of an inch wide to be clearly visible and two such lines ruled in parallel on the paper must have a space between them at least 0.0045 inch wide in order that they may be seen as two distinct lines; with a smaller space between them they will appear as one wider line.

In the visual inspection of silk these visibility and differentiation factors must be kept constantly in mind. To see a looped portion distinctly it must be separated 0.0045 inch from the main portion of the thread. To see differences on opposite sides of a silk thread it must be at least .0045 inch in diameter. By this kind of analysis we are led to see how much of the general real appearance of the raw silk thread may escape us on account of the limitations of human vision. The almost continuous variation in the diameter of the thread, for example, is not noticeable unless there are considerable abrupt variations or the variations have been magnified by projections on a screen.

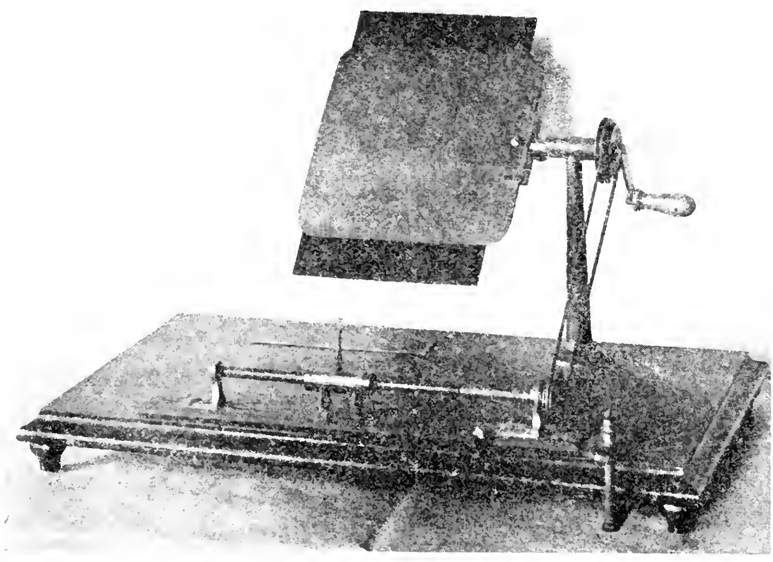


Fig. 86

The usual apparatus for making the eleven-inch by seven-inch mirror inspection cards is shown in Figure 86. It consists of a spindle, one end of which clamps two thin pieces of sheet iron, between which the black card is held while the silk is wound on it by turning the handle at the other end of the spindle. The card with the silk wound on it is removed from the clamp by simply slipping it side-wise out of the clamp. The number of threads per inch may be varied by changing the belt from one set of the cone pulleys to another, thus increasing or decreasing the angular velocity of the screw relative to the angular velocity of the spindle. The apparatus as a whole is very simple and is satisfactory for small cards.

Various devices have been developed for the purpose of showing more silk than is shown on the small cards of Figure 86. Some of these devices are simply the mechanical variations on the plan of Figure 86 necessary for holding larger cards, which sometimes are rectangles sixty-inch by thirty-inch in size. It is not necessary to go into the details of these large card machines as in general principles they are illustrated in Figure 86. One device developed in

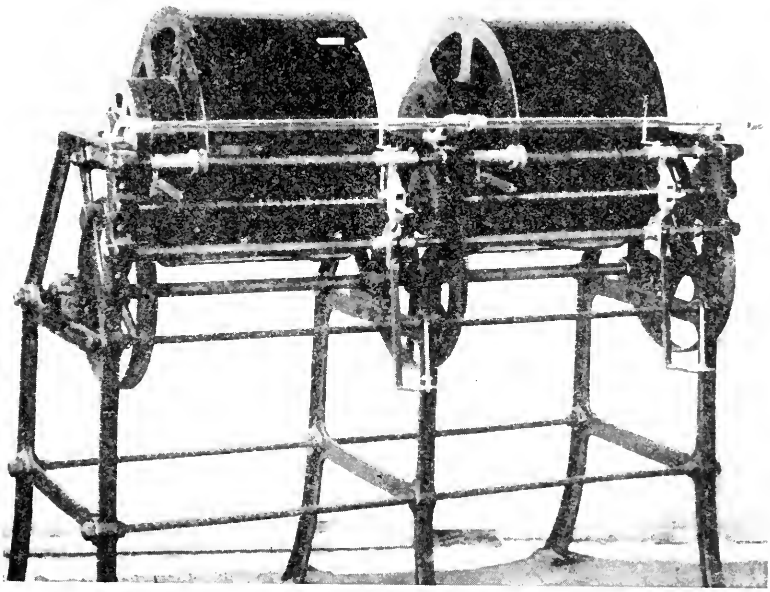


Fig. 87

this country and made in Newark, N. J., substitutes for the card of Figure 86 two rectangular cards about sixty inches long and eighteen inches wide intersecting each other along their middle lines at right angles so that the intersection is the axis of a reel and their outer edges are the reel bars of a four bar reeling machine. The machine may be furnished with a number of these reels, so that some may be winding while others covered with silk may be inspected. In this case the cards do not touch the silk except at their edges and furnish a dark background not in contact with the silk. The reels are covered with silk by winding from several bobbins at the same time so that the winding is done quickly and may be from ten bobbins taken from the regular ten sample skeins.

In using large card inspections one must be careful not to reach snap judgments from the general appearance of the card in the one "glance-over" way. The inspection should be made over small areas separately by count in so far

as evenness and major cleanness defects are concerned, and may be guessed in so far as minor cleanness defects are concerned. It will be found that close attention to the two elements of human visibility mentioned above will be an advantage to the inspector.

Figure 87 is an illustration of a Japanese device for showing a considerable yardage on a cylinder whose surface is marked off into rectangles by red lines. The cylinders are constructed with a portion hinged and held in place by a spring. This portion may be pushed in on one side as shown in the left hand cylinder of the figure, thus loosening the threads so that they may be pushed off over the end of the cylinder without breaking. The axle of the cylinder can be lifted out of its bearing in order to remove the silk from the machine.

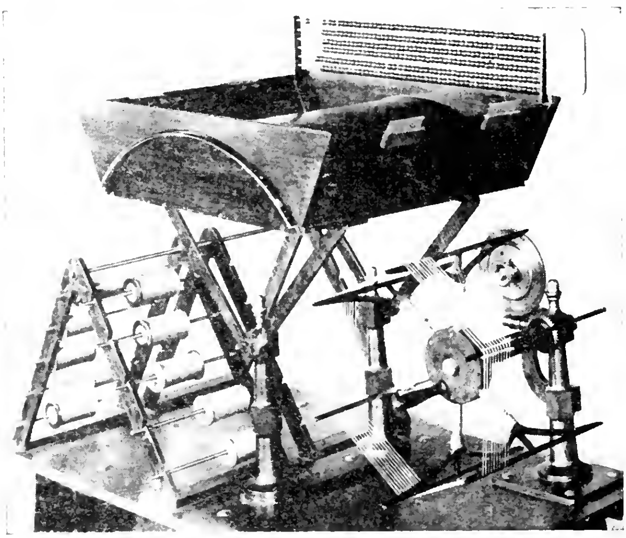


Fig. 88

Figure 88 shows a device originating in Switzerland to act as a sort of continuous card inspection machine. The silk is wound from several bobbins onto a reel, passing through two sets of reeds at opposite sides of a curved mirror. Two mirrors are furnished with the machine, one black and one white; either may be removed and placed over the other. The machine is furnished with a Chinese abacus counting device for counting six different kinds of defects as the silk passes over the mirror.

In passing on to the consideration of the gage test, I might mention that in making a careful count inspection by using any one of these card devices, it will be found that there is an eye strain that can only be endured for a short interval of time. A good light is essential and the eye should be relieved by alternately doing something else at frequent intervals.

The Gage Test

The gage test as a means of determining the evenness and cleanness defects in raw silk is, in the judgment of the writer, the most practical test for this purpose that has so far been tried out. It is not all that could be desired by any means in several important particulars; but, nevertheless, it comes nearer to giving the important defects in numbers per given length than any other test, and with a minimum of eye strain and personal intuitive judgment. In competent and experienced hands it is a test that checks itself closely enough for most practical purposes.

The fundamental idea of the gage for the testing of raw silk is based on the diameter of the silk thread. The gage as now made for the gage machine is a modified and more accurately adjusted very narrow V-shaped slot than that first introduced by the successors to Gospard Honeggar, at Ruti, in Switzerland, over twenty years ago in a machine for recleaning raw silk by running it through a quickly adjusted V-shaped slot under suitable conditions of speed and tension.

The gage shown in Figure 23, Chapter VI., consists of two bars of hardened tool steel of rectangular cross sections with two accurately plane surfaces facing each other and bolted together so as to form a narrow V-shaped slot, which has graduations along one side of it, indicating the denier size of the silk that will run through at that point without breaking except when a defect passes into the slot.

The fundamental idea in the graduation of the gages is the diameter of the raw silk thread. If the raw silk thread was a compact body of strictly cylindrical form and of homogeneous material, the computation of its diameter could be accurately made from the weight of sizing skeins and the specific gravity of the silk. The formula for this purpose would be $W = 45000 \| r^2G$, in which W is the weight of the sizing skein in grams, 45000 is the length of the sizing skein in centimeters, $\|$ is 3.141, r is half the diameter and G is the specific gravity of the silk.

The specific gravity may be placed at four-thirds for all mulberry silks without appreciable error. This corresponds to the specific gravity found by Vignon, 1.33 to 1.34, and published by Silberman as correct. In the laboratory of the United States Testing Company, Inc., the specific gravity of mulberry silks has been found to be very approximately: 1.34 for White Japan and Shanghai Steam Filatures; 1.35 for Yellow Japan and 1.36 for Canton.

Since the graduation of the gage depends on a diameter corresponding to the denier size of the thread, it is expedient to put for W in the formula its equivalent D/20, where D is the size in deniers. The formula then becomes $D/20 = 45{,}000 \| r^2G$. Putting in the numerical values for $\|$ and G and rearranging we have $r^2 = \dfrac{D}{1{,}200{,}000 \times 3.1416} = D/3769920$ from which we get a value for $r = \sqrt{D}/1942 = K\sqrt{D}$, say; from which it appears that r and therefore 2r (diameter) varies as the square root of numbers representing the size

in deniers. Taking D = 9 we get from our formula, r = 3/1942 = 0.001545 centimeters, 15.45 microns, and the diameter is 30.9 microns. Since the diameter varies as the square root of the size in deniers we can now give the diameters for sizes 9, 16, 25 and 36 deniers without a table of square roots as respectively 20.6. 30.9, 41.2, 51.5, and 61.8 microns. As a matter of fact the working diameters are somewhat greater. Rosenzweig in "Serivalor" gives the diameters respectively for the sizes named above at 29.5, 44.3, 59, 73.8 for the first four. These diameters are roughly one and one-half times as great as those computed by the formula.

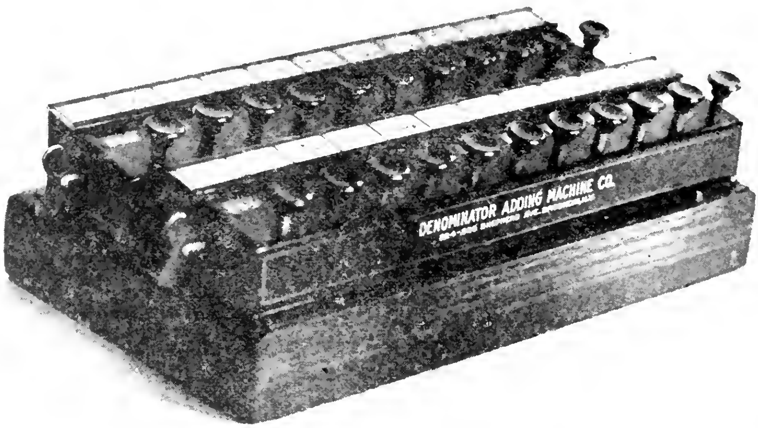


Fig. 89

In the laboratory of the United States Testing Company, Inc., a series of five tests has been made on different sizes of each of Shanghai Steam Filature, Canton, Yellow Japan and Italian raw silks in order to furnish a rough check on the Rosenzweig diameters, which were obtained by winding certain lengths of known weight on black mirrors with the adjoining threads in close enough contact so that a linear magnification of 8x showed neither gaps nor doubling. (This statement should not be taken too literally.) The number of threads per inch was then determined, from which it is easy to find the average diameter. The check tests made by the Testing Company gave average diameters roughly one and one-half times as great as those computed from the formula and in good enough accord with the diameters of Rosenzweig to indicate that he obtained diameters nearly enough correct to be adopted for practical uses.

Some attempts have been made to show that the actual diametrical dimensions would be greater than the theoretically computed diameter, if a silk thread were considered as made up of cylinders lying in parallel. This is a futile speculation since the baves are not cylindrical.

Rosenzweig states that the actual diameter in the case of four bave threads, say, will be to the theoretical in the ratio of the area of a circumscribed square to the circle, i. e., $4r^2 / \pi r^2$ or as 4/3,1416, making the actual diameter about 1.27 times the computed one. As a matter of fact, the computed diameter for the equivalent of the four bave thread in the above assumption would be twice that of one of the baves, or 2D, 2D multiplied by 1.27=2.54D, which is somewhat larger than the maximum diameter AB shown in Fig. 12. AB is 2.41D by the geometry of the figure. The reader grouping 5, 6, 7, 8, etc., will find that seven cylinders make a very compact group of six around one.

The gage machine as now made by the Testing Company is shown in Fig. 24, Chapter VI. The gages, ten in number, are mounted on a bar that can be racked backward or forward so that the silk thread shall pass through at the place marked for its average size, which must be known before beginning the test.

The test consists in running a certain yardage through the gages and counting the defects of different kinds that cause breaks as the silk passes through the gages.

Figure 89 shows a counting device that is handy but not essential. Ruled paper with the name of the defects printed or written at the left hand end of the lines may be used quite effectively by making the count on each line groups of five dashes and placing the sum at the right hand end of the line, as:

Weak threads	11111 11111 1111	14
Slugs	11111 11111 11111 11111 11	22

etc., etc.

It has been urged against the gage test that the gages do not catch all defects, more particularly fine ends. It catches enough fine ends to place the silk in its class and is as repeatable in this respect as any practical test known to the writer. That it does not catch all the loops, nibs, etc., among the minor defects is in its favor; it only catches those that are large enough to be harmful enough to warrant counting in the test.

Given an unbiased and prolonged trial, the gage test will be found worth while, though admittedly not everything one could wish. It is worthy of a thorough tryout in a large number of laboratories and should be used until something better is established. Its findings should be compared with all other tests made for the same purpose. The more tests of different kinds for the same purpose the better. In order to adopt finally any one as superior to the others, a large number of comparisons must be made. The more comparisons from different laboratories the better.

The research laboratories of the U. S. Testing Co. stand committed to making the comparisons if only the other laboratories will submit data for the

purposes, and will gladly make check tests on raw silk sent to it by manufacturers and others. It is very anxious for data of tests accompanied by mill run checks, and hereby commits itself to careful attention to all such data submitted. Let us get together all the data possible to the end that we may more speedily arrive at a definite working conclusion that shall be of benefit to all users of raw silk.

The Cohesion Test

There is so much apparent confusion as to the meaning of cohesion when applied to raw silk threads, that it seems advisable at the outset to state that no attempt will be made here to decide whether it should more properly be called a friction test, or whether it is logical to refer to it as a "soul-of-silk" test, or whether it is really the only test required for determining the quality

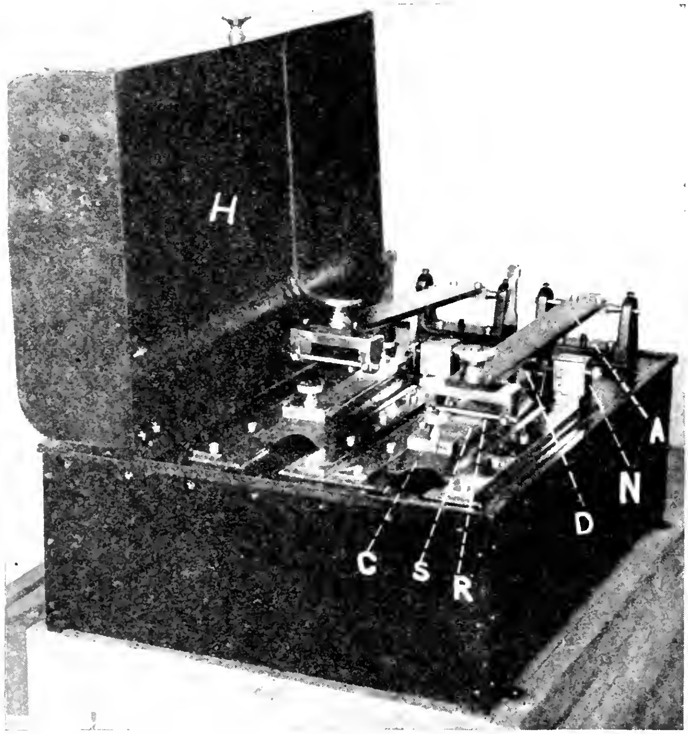


Fig. 90

of the silk from the manufacturers' point of view, etc., and say frankly that it is considered only from the point of view of determining a relative value of different raw silks to withstand separation of the threads into the individual cocoon baves from which they are made (an indication of the compactness of the agglutination).

The test as made on the Seem Cohesion machine is the only one that will be considered in this paper. Figure 90 shows the machine as improved and manufactured by the United States Testing Co., Inc.

The test is made by subjecting fifty threads in parallel on a suitable surface (compact black cardboard), to the rolling action of a small weighted very hard roller R capable of moving freely about its axis on pivots, while the card holding the fifty silk threads moves to and fro under it in the direction of their length. The axis of the roller makes an angle of 87.50° with the direction of this to and fro motion, thus giving a combination of rolling and sliding friction on the threads.

The cohesion quality is indicated by the number of strokes (to and fro motions of the card), required to separate the threads into the cocoon baves from which they were made. The number of strokes is recorded by the counter N. One can tell quite easily in a good light when this breakdown is complete by placing an artists' spatula between the threads and the card (removed from the clamps for the purpose), from time to time and carefully examining the threads. A fairly good agglutination generally requires one thousand or more strokes.

Many objections have been raised to this test. It is easy to offer objections. What we need is not objections to the test, but something better offered as a substitute.

Some object that its findings are only applicable to silks for single weaving, and that it does not imitate this weaving action at all. So far the writer has not found one of these objectors who is willing to go on record as having proved the unreliability of the relative values as found by this test when checked against mill "runs." Others object that too much has been claimed for the general value of its findings. This is doubtless true, but why condemn the test because some enthusiast gives too large meaning to its findings?

I wish to call attention to one objection in particular. It is pointed out by some that the filature operators will "beat" the test by keeping the water in the basins at a high enough temperature and sufficiently gummy, and by drying on the reels at just the right rate. The test will have proved its utility if this way of "beating" it is successful.

I shall conclude this subject by giving a few examples from the old and the new way of conducting this test. The old way was to take ten threads from each of five skeins to make up a card. Four cards were made from twenty different skeins and the strokes averaged. Table 16 shows the findings of five such tests typical of the higher averages.

Table 16

	Test 1	Test 2	Test 3	Test 4	Test 5	
Card No. 1	1000	2000	1400	2050	2400	strokes
Card No. 2	900	1150	1600	1850	1750	strokes
Card No. 3	1150	1500	1500	1750	2850	strokes
Card No. 4	1100	900	1450	1650	2300	strokes
Total	4150	5550	5950	7300	9300	strokes
Average	1037	1387	1488	1825	2325	strokes

Tests 1 and 3 show even sets of cards. Sets showing wide variation in number of strokes of the four cards are much more usual, tests 2 and 5 being typical.

The new way of making up the cards for the test differs from the old way only in taking the fifty threads for each card from the same skein, each card being made from a different skein. Table 17 shows four such tests.

Table 17

	Test 1	Test 2	Test 3	Test 4	
Card No. 1	500	1100	1150	2600	strokes
Card No. 2	500	1050	850	2600	strokes
Card No. 3	500	1250	900	2650	strokes
Card No. 4	500	1150	900	2650	strokes
Total	2050	5550	3800	10500	strokes
Average	512	1387	950	2625	strokes

It should be noticed in comparison that the greatest variation in the number of strokes is in Test 3, when Card 1 shows thirty-five per cent more strokes than Card 2. This is an unusual difference suggesting that Card 1 should be repeated.

These four tests are from four different skeins, from four different books out of the same bale. Now, if we assume for the moment that Card 1 of Test 3 has been repeated and it is found 900 strokes are required, instead of 1150, we shall have a fairly representative set of cards in each of the four tests. The average strokes for each test will not usually show such a large variation, the average in Test 4 being more than five times the average in Test 1.

The significant thing is that in the same bale, which may be assumed to be made up of skeins from the same filature all made from the same grade of cocoons, there are such wide differences in the tests. If the filature operators become convinced that it is necessary to "beat" the cohesion test so that such wide difference shall not exist, the writer would suggest as a start that careful attention be given to the condition of the water in the basins, both as to uniformity of temperature and gumminess, the speed of reeling, the rate of drying and the croisure. If these elements of success are all given proper care, it may be found in the future that good agglutination is more common and waviness and loopiness less common in silk threads.

"LOUSY" SILK

D. E. Douty and K. B. Lamb, United States Testing Co., Inc., in SILK.

During the years 1913-1914 there was a considerable increase in the number of complaints of "lousiness" and of unusual flossiness in dyed silk yarns. From the nature of the inquiries received at the Testing House there is evidently a diversity of opinion in the silk trade as to what is meant by the term "lousiness."

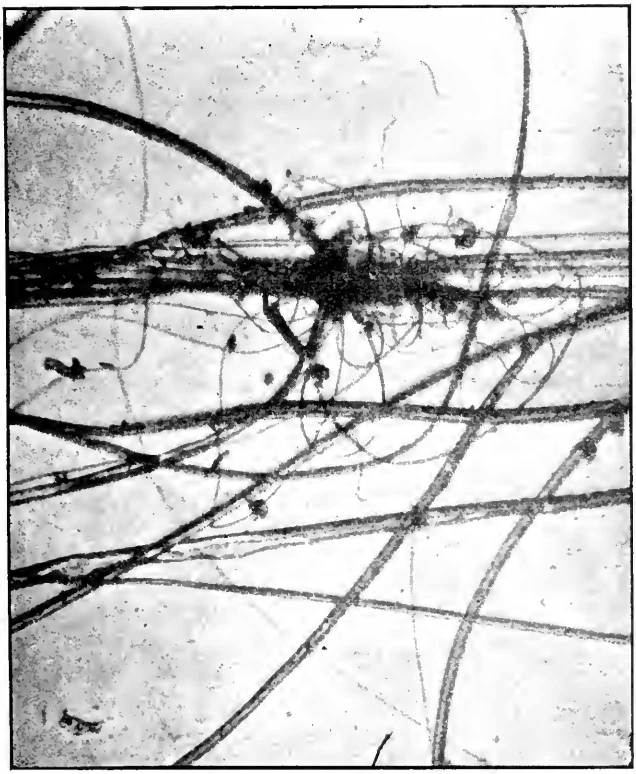


Fig. 91. Silk boiled off seven minutes, magnification 150 diameters; showing lousy markings, silk lint and fibrillae.

Imperfections in skein dyed silk may be grouped into four classes; i. e.:

(1) Those existing in the silk filament as it comes from the cocoon.

(2) Those caused by faulty reeling of the filament from the cocoon into the raw silk thread such as duvet, vrilles, fine ends, double ends, slubs, nibs, knots, imperfectly cemented filaments, etc.

(3) Those due to bad throwing, improper soaps or oils used in soaking, or to rough handling.

(4) Those caused in the boiling off and the dyeing processes.

If only the skein-dyed silk yarn is available for examination it is usually impossible to locate definitely the causes of the imperfections or indicate the group to which they belong.

Lousiness belongs strictly to the first class. The flossy condition caused by it may be aggravated by rough and improper handling or kept at a minimum by careful handling, but primarily it originates in the raw silk.

Construction of the Raw Silk.—The single "bave" or "end" as it comes from the spinneret of the worm is composed of two filaments of fibroin, secreted by the two glands and cemented together by sericin or gum. Each filament of fibroin is itself composed of bundles of exceedingly fine fibrillae also cemented into a compact mass by the sericin.

When a normal silk is prepared for dyeing, a portion of the gum is boiled off. A sufficient amount remains to cement the two filaments and the fibrillae, of which they are composed, compactly together and the thread remains smooth and lustrous. If insufficient gum remains to hold the filaments together they separate and form a loose soft thread, the ends split, the silk becomes flossy, and, in extreme cases, the filaments themselves separate into the fibrillae and the silk becomes very flossy.

Even normal silks differ quite widely in the ease with which the gum dissolves. The dyer regulates the boil-off to suit the material and the process to which it is to be subjected later.

Silk as an Abnormal or Imperfect Raw Silk.—In this article the term lousiness is used to describe the tendency which the original bave, as it comes from the cocoon, has to split into its elemental fibrillae and become usually flossy upon being degummed in a neutral solution of olive oil soap and water. It does not refer to any mechanical defects in reeling from the cocoon such as duvet, vrilles, knots, imperfectly joined baves, etc.; nor, as is so often done, to any imperfections classed above under groups 91 and 92.

It is impossible by the ordinary methods of visual inspection and touch to detect lousiness in raw silk.

The characteristic markings on the filament are so small that they can only be seen by the use of the microscope and cannot be detected by the "feel" of the silk.

This fact led a special committee of the Silk Association of America in April, 1904, to make a report, which was approved by the Board of Managers of the Association, as follows:

(1) "The fact that raw silk is 'lousy' cannot be discovered in the raw inspections as usually practiced.

"It is a well established fact that raw silk of soft nature shows as a rule the defect in question to a much greater extent than raw silk of hard nature when dyed.

(2) "If raw silk is delivered and accepted according to accepted sample, or according to classification agreed upon, the responsibility is the buyer's and not the seller's.

(3) "The raw silk importer's responsibility ends when silk is delivered and accepted according to stipulations of contract."

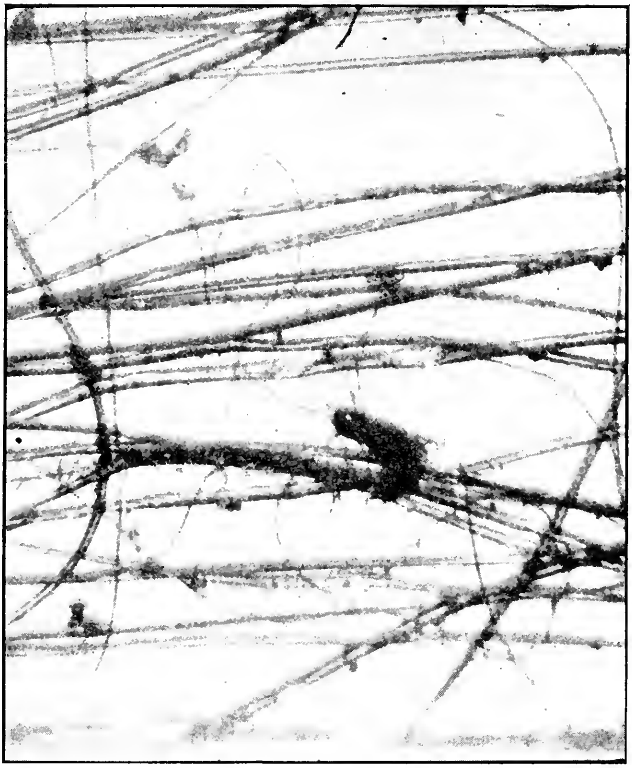


Fig.92. Silk boiled off ten minutes, magnification 150 diameters; showing same condition as in Fig. 91.

Lousiness first becomes apparent to the manufacturer after the silk is boiled off and dyed. The yarn is excessively flossy and in most cases there appear on it numerous white or light colored specks resembling dust or lint.

It was thought by those who first considered the matter, that the trouble was caused by some insect or parasite which was known as the silk "louse," and the word "lousiness" was a natural result of this erroneous idea.

Lousiness comes of course from no such cause and is a misleading and incorrect word. It has been used by the trade for so many years and so universally, that it would be difficult to substitute a better and more fitting term.

An examination of the specks by means of the microscope shows that they are masses of the exceedingly fine silk fibrillae matted and tangled together.

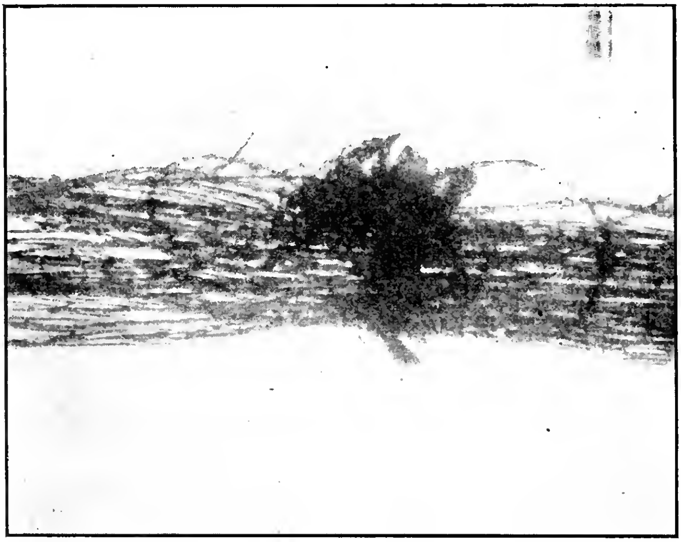


Fig. 93. Boiled off, dyed, three thread tram; magnification 75 diameters

They may occur regularly or irregularly and may be very plentiful or few. They give the skein a dirty, dusty appearance and the term "Lousiness" when used in the slang sense really describes this appearance very well and is probably one reason why the term is in such popular use. The fact that they do not seem to take the dye has led many to believe they are composed of some foreign material.

Silk Lint.—Since these defects are composed entirely of silk and resemble dust or lint we suggest that they be called "silk lint."

From recent studies of samples submitted for examination a possibility seems to exist that there may be defective silks which split up very easily and become excessively flossy upon comparatively short boiling in a solution of neutral olive oil soap but which do not show "silk lint" after dyeing. There is also the possibility that there may be silks which do not show the swellings and cross

markings in the raw thread but which upon light boiling split up and become excessively flossy. We hope to secure and report later upon these two possibilities.

It is exceedingly important for the protection ot all branches of the silk industry that some quick, reliable and dependable method should be found for detecting "Lousiness" in silk before it has reached the advanced stage of manufacture and becomes useless for the less exacting uses to which it might have been applied. Since the importer has been unable by his ordinary methods of inspection to discover the defect in advance, he has by custom been somewhat relieved of responsibility. Notwithstanding this concession, every importer who is interested in developing his business and maintaining a high standard in the industry is vitally interested in finding some means that will assist him in preventing the importation of raw silk having this fundamental defect. Since

Fig. 94. Boiled off, dyed organzine; magnification 150 diameters.

America is not a producer of raw silk very little can be accomplished towards determining the cause of "Lousiness." We should, however, be able to accomplish something towards a method for detecting it.

The present status is as follows:

Microscopic examination of the raw thread will detect the irregular markings and swellings on the fibre and when they are present in numbers exceeding the usual and allowable number of nibs, slubs, etc., there is a great probability that the silk will become unusually flossy. Boil-off tests on small portions should be made on the raw and on small samples of thrown. In well defined cases such a procedure furnishes results upon which definite conclusions can be drawn. When, however, the defect is only slightly present the decision as to whether it is sufficient to prevent the use of the silk and to classify it as lousy is very difficult.

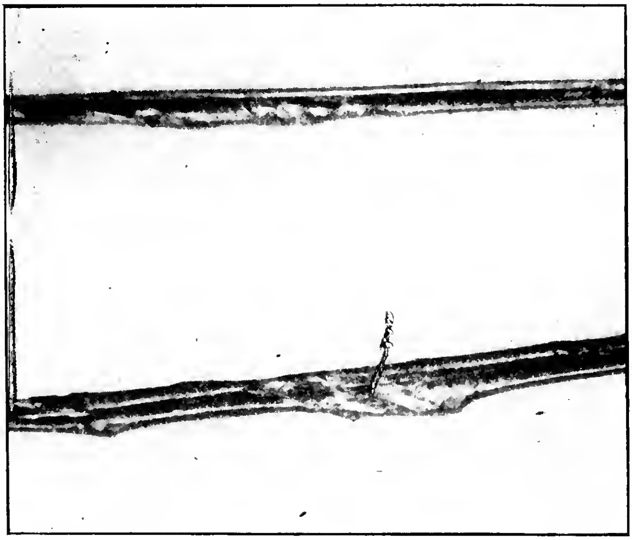


Fig. 95. Raw silk; magnification 150 diameters. Two baves showing characteristic swelling and markings of lousy silk.

The dyers are at present receiving much of the blame and in many cases unjustly.

We have had samples of raw silks that showed evident tendencies to split up with three minutes' boiling in a solution of the very best neutral olive oil soap and to become unusable after ten minutes' boiling. It is very doubtful if such a silk could be boiled off in the skein in the regular commercial quantities, with even the most careful handling and best materials without becoming excessively flossy. Combine with such a defective silk an order to give it a twenty or thirty ounce dye and the dyer's task is almost impossible.

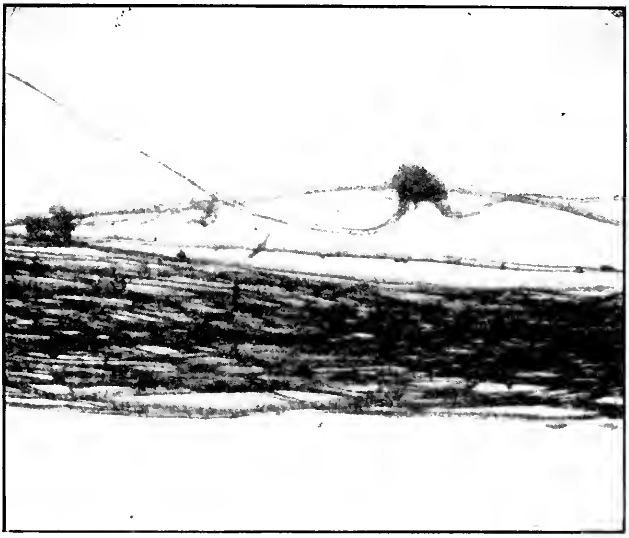


Fig. 96. Boiled off, dyed, three-thread tram; magnification 75 diameters.

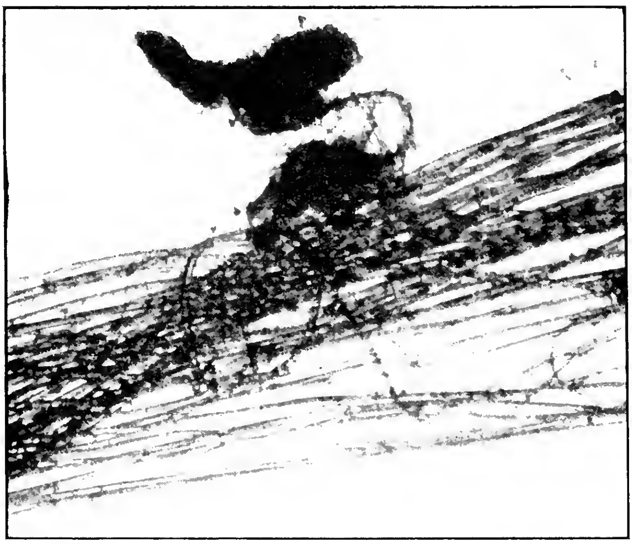


Fig. 97. Boiled off, dyed, three-thread tram; magnification 75 diameters.

During the investigation of lousy and defective silks many photomicrographs have been made. We have chosen the ten accompanying ones as illustrating typical examples of lousiness.

Figure 95. Raw silk; magnification 150 diameters; shows two baves or cocoon ends having abnormal swellings and cross striations which are so frequent in lousy silk. On boiling off the silk these lumps partially split up into the very

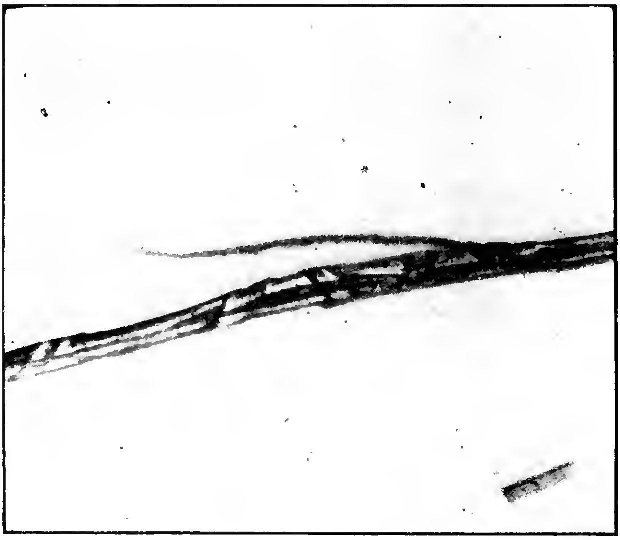


Fig. 98. Raw silk; magnification, 150 diameters. Single bave showing lousy markings and split filament.

fine fibrillae, and are evidently due to faulty secretion of the fibroin by the worm. This photomicrograph also clearly shows the formation of the bave, i. e., how it consists of two filaments cemented together by the sericin or silk gum.

Figure 98. Raw silk; magnification 150 diameters. This photomicrograph shows more of the cross markings found in lousy silk. In addition it shows how part of the filament has split off from the main filament. If this silk was boiled off the detached part would further split up into the small fibrillae.

Figure 91. Silk boiled off seven minutes; magnification 150 diameters. Shows how lousy silk splits up into elemental fibrillae even after a very short boil-off. The fine hair-like lines are the fibrillae which have split off from the main filaments and the dark mass in the center of the photograph is a bunch of these matted together.

Figure 92. Silk boiled off ten minutes; magnification 150 diameters. Shows the same condition as in the former one, i. e., a tangled mass of the fibrillae.

Fig. 99. Boiled off, dyed tram; magnification 150 diameters.

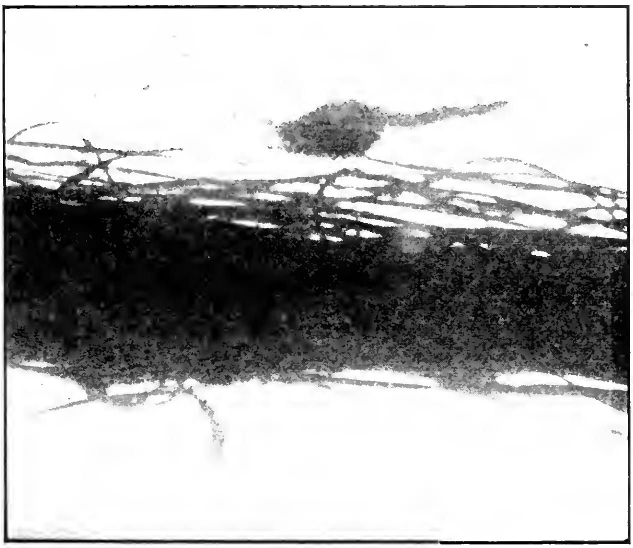


Fig. 100. Boiled off, dyed tram; magnification 75 diameters.

Figure 96. Boiled off dyed silk, three thread tram; magnification seventy-five diameters; an excellent photomicrograph. The fibrillae can be seen splitting off from the fibre and collecting in a bunch. When these bunches are large enough to be seen they appear as the light-colored specks before mentioned which we propose calling "silk lint."

Figure 97. Boiled off dyed silk, three thread tram; magnification seventy-five diameters. Here we have the same condition as above in a more exaggerated form. Fibrillae can be seen all through the silk and a tangled and matted mass has collected at a point where there is a loop on one of the filaments.

Figure 93. Boiled off dyed silk; three thread tram; magnification seventy-five diameters. This shows another similar case with the "silk lint" firmly attached to the thread.

Figure 99. Boiled off dyed silk, tram; magnification 150 diameters. This photomicrograph shows a small speck of the "silk lint" on the surface of the thread. The fibrillae are again in evidence as they always are in cases of lousy silk.

Figure 100. Boiled off dyed tram, magnification seventy-five diameters. This also shows the matted fibrillae, this time very lightly attached to the surface of the thread.

Figure 94. Boiled off dyed organzine. We here have a large matted mass of the "silk lint" in connection with a tangled knot of a filament. It is usually a fact that the "silk lint" is found at some portion of the thread that has a knot, snarl, or other obstruction upon it. The obstruction affords a good collecting place for the fibrillae which partly mass together during the boil-off, dyeing, winding and spooling of the silk.

There are several theories which attempt to account for the fact that the "silk lint" looks white or light colored. We believe the following to be the best explanation of this condition:

The fibrillae of which the "silk lint" is composed are exceedingly fine and of very much smaller diameter than the main filament. Therefore the fibrillae are much more transparent than the main silk fibre. This would allow more light to come through and a light color would result. Also the reflection and refraction of light would be very different in the case of the microscopical fibrillae from that of the larger filament.

An illustration of the effect of size of particle upon color may be seen in copper sulphate (blue stone). If it is in lumps and large pieces the color is a beautiful deep blue, hence the name "blue stone." If the lumps are crushed into fine powder the color becomes bluish white, but the composition has not been altered. The effect is therefore due entirely to the difference in manner in which the particles transmit, absorb, reflect and retract light.

Possibly the fibrillae do not absorb the dyestuff in the same manner as the filament, and there is also the possibility that the center of the tangled mass may contain some undissolved sericin which does not take the dye and therefore remains white or light colored.

A more detailed study than any which has yet come to our attention must be made of the "silk lint" before positive knowledge is at hand regarding its chemical composition and its action with dyestuffs.

In Ravelings or Lousiness published by The Silk Association in 1906 by permission of the late Signor Guiseppe Corte, Director of the Silk Conditioning House at Milan, Italy, we find the subject of Lousiness very thoroughly described. Under Chapter III we read:

The formation of dots in dyed silks is especially damaging on account of the reduced lustre caused to the texture, which suffers a depreciation of value in relation to the number of microscopic ravelings of fibrillae that are found scattered on its surface.

Since it has been proved that no silk is exempt from exfoliating and even the best show a number varying between ten and 100 per 1,000 meters of thread according to the method followed in the degumming operation, one can understand that the task of the dyer must be to keep the proportion between limits that do not tarnish the appearance of the fabric.

Practice has demonstrated that the presence of 100 to 150 "nibs"(fiocchetti) per each 1,000 meters in thread used for material ordinarily manufactured, does not damage the appearance of the fabric and it is only when the nibs amount to several hundred that the effect becomes disastrous. As the success of many fabrics is due to the judicious selection of the thread, and the exterior appearance of the raw silk does not give a reliable indication about its susceptibility to take on dyes uniformly and to produce the required results, the manufacturer can only resort to the direct examination of a small sample, and submitting it to tests calculated to ascertain the quality of the silk which he proposes to use.

Especially when the purchase is of thrown silk of unknown source or when new articles are to be manufactured, it would be always advisable to have a trial of degumming in two successive three per cent soap baths and for the duration of half an hour, as is practised in conditioning establishments for official trials of boiling off (1). This operation should be followed by dyeing to make the nibs more perceptible so as to compare threads among themselves, or with fabrics of given lustre. The operation can be made more easy by winding the threads on a varnished board, disposing them side by side so that they cover a given portion of it. The apparatus made for this purpose by Henry Baer & C. is shown in the illustration Fig. No. 101.

Wishing to proceed to the numbering of nibs (fiocchetti) the process indicated by P. Francezon for the defect of raw silks is followed. It consists in having the threads to be examined—three or four in number—pass on a table of opaque black marble unwinding them from bobbins with a speed varied according to the sight of an experienced reeler having his or her eye especially trained to discern the abnormalties of the thread and to distinguish the defects of reeling from those owing to exfoliation and raveling of the fibrillae. If an experienced reeler is not at hand, recourse can be had to the projection apparatus, supplied with adjuncts to reel and wind the thread according to the dispositions conceived by Koristka to change the speed according to necessity.

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(1) It is clear that the silks which can stand the usual operation of boiling off will resist even better when the dyer shall have applied the improvements which we shall mention further on. In the dye-shop the boiling off is usually performed at a temperature below 100 degrees and with two soap baths, the first of which is prepared with twenty to thirty-three per cent of soap to the weight of the silk, and the second with one half. For silks that are to be dyed in dark colors the second bath is not infrequently used for the degumming of a subsequent parcel.

The results that are obtained by the above-said method are not however to be compared to those obtained by examining the threads with the help of a microscope, for a magnifying apparatus makes conspicuous also the imperfections that the naked eye cannot discern and that a manufacturer can overlook, as they have little influence on the commercial value of the fabric.

Concerning these tests it is not to be forgotten that the threads do not offer a uniform structure and consequently the results are valueless if the test is confined to short portions of thread.

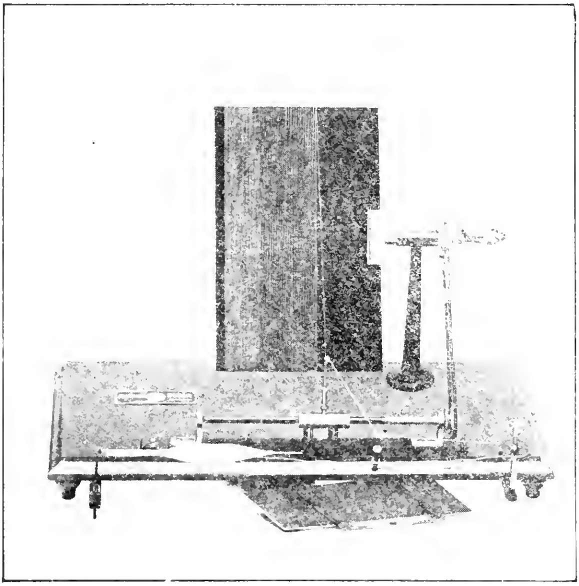


Fig. 101

In order to get a clear idea of the fluctuations exhibited by a single quality of silk, we had a skein ungummed and dyed, the heating being done in a vessel immersed in boiling water—and afterwards we caused the nibs to be numbered on 16000 metres. The results obtained prove that the number may vary between a maximum of 251 and a minimum of 42 per 1000 metres, when the examination is confined to 500 metres. Extending it to 2000 metres, the greatest variations, — deducted from the average results of four series of trials on 500—were reduced to 53: 119; by examining 4000 metres the relation became 81: 175, and finally with 8000 metres it became 107:158. Besides making a considerable number of observations, the aforesaid tests must be made on threads of the same "size" and of the same twisting, for — as was to be expected — the threads in which the fibres are less tightly pressed together on account of imperfect throwing — as often happens in tram — are in a condition to make the defect more evident than is the case with organzine which generally appears less defective. The manufacturers are consequently exposed to greater risks with goods in which tram is used to give effects in fabrics where a great lustre is sought.

In tests directed to find out whether silks of a given source are subject to exfoliate more than usual, one factor cannot be neglected that has an influence on the whole appreciation of the defect; it originates in the color given to the silk which changes the grade of perceptibility or visibility of the nibs. The raveled fibrillae appear more or less evident according to the intensity of penetration of tinctorial substances in the nucleus of fibroin and to the intensity and nature of the colored rays reflected by the fibre. On this account the threads of a single quality appear unequally defective when we pass from light monochromatic to trichromatic colors. Desiring to ascertain how much the number of nibs on the same thrown silk can vary we have dyed in our laboratory under conditions quite identical, the same silk in the following colors; and proceeded afterwards to the test of comparison.

	Number of nibs per 1000 meters
Thread of white silk..................	378
Thread of yellow silk..................	481
Thread of green silk..................	383
Thread of red silk......................	356
Thread of blue silk.....................	264
Thread of black silk....................	115

It appears that the visibility of nibs (fiocchetti) is lessened when the silk is dyed black and is the greatest in yellow. This result confirms the observation of experienced users of silk who affirm that the dark yellowish colors are those giving rise to the most complaints.

Even when the manufacturer has a clear idea of all the factors that have an influence on the lustre of a fabric and has regulated the purchase of silk in relation to them. the result is always subordinate to the work of the dyer, who in his turn has difficulty to overcome in order that—especially following the boiling off—the silk may keep its lustre unaltered. If the threads were always of the same nature, it ought not to be difficult to settle the conditions under which the degumming may be accomplished without inducing splitting, but as they differ in the kinds of work, the size, degree of twisting, manner of winding and stretching, the work of the dyer becomes very difficult. Having to dye for third parties, he has no way to find out the source and the age of the silk entrusted to him. Even if aware of his duty to make opportune tests in advance of boiling off in order to recognize the nature of the silk, and to classify it with the purpose of timely modifying of the boiling off process according to the quality of the thread, he generally studies only the organoleptic characteristics which are uncertain and cannot always be helped by the customary tests, as these concern the thread and not the original fibre by which the former is made.

Even if the dyer were aware of the quality of the silk which he receives daily from manufacturers, it would not be possible for him to take into consideration all the factors that have an influence on the results of the boiling off; not only because it is not easy to establish their entity, but also because the compensation which he receives for the degumming and dyeing does not allow him to keep always separate the different parcels and to proportionate the duration of the boiling off in the soap bath with the nature of the thread.

In many cases he is obliged to treat in the same way silks of a low quality and little twist, subject to a loss of fifteen to sixteen per cent ;—with others that lose in the bath only sixteen to seventeen per cent of sericin, or gum. Sometimes the silks have received—in order to facilitate the throwing—a treatment with special fatty preparations not easily dissolved in soapy solutions, or were treated with substances like tin salts or phosphate or borate of sodium that cause the fixing of earthy salts.

In these cases the common boiling off is not sufficient and more energetic treatment becomes necessary, damaging the quality of the silk. We should not be surprised consequently, if now more than formerly are noticed bad results due to the boiling off pell-mell of silks in hot and concentrated soapy solutions.

Formerly the silk was degummed in large kettles, putting it in linen sacks that were stirred with a stick and with this primitive method there was no complaint whatever as long as only Italian silks were prevalent in our dye shops. But after 1875 when the Levantine silks came in larger quantities to our markets, the necessity became evident to have recourse to rectangular vats supplied with pipes for the accession of steam; thereon the silks were hung in order to regulate the boiling according to the quality of the silk. If on one side this innovation was advantageous, we cannot maintain that it was likewise so for the uniformity of the heating; and the doubt is not without foundation that in many cases the disparities observed in the number of nibs between the silk degummed in industrial shops and those that were subjected to the same operation in our laboratory, arise from the fact that the portions nearer to the steam pipes are exposed to an excessive heating.

Judging from the results obtained by degumming the silks kept motionless, we could believe that the process contrived by M. Michel of Lyons to take the gum off—described by Dumas in 1846 in his treatise of applied chemistry and consisting in subjecting the silks, saturated with a soapy solution, to the action of steam in a vessel hermetically closed—should spare the silk the stretching to which it is subjected and which is the cause of the lesions so much deplored. But the application of this contrivance—that was also patented in England by Messrs. Fortier and Philippe—turns out difficult not on account of the danger of explosion of the apparatus—as admitted by many authors—but because the silk loses sensibly its tenacity when exposed to a higher pressure than that of the atmosphere in the presence of soap.

The following tests give an idea of the influence exercised by the degree of heating in a bath protracted for an hour with a three per cent soapy solution.

Average of Thirty Dynanometric Tests

	With bath in vessel immersed in boiling water	At 100° C	At 102° C	At 105° C	At 110° C
Ductility	100	98.8	94.1	93.6	88.5
Tenacity	100	98.6	94.2	93.5	85.5

These results demonstrate the necessity of working—as far as possible—at a moderate temperature; in fact in our tests the best results were always obtained

when the degumming was made in a vessel immersed in boiling water, keeping the silk completely submerged.

Under these conditions the degumming is complete in one hour and the number of exfoliations turns out considerably less than those obtained with the ordinary boiling off method, but the volume of the soapy solution required is considerably more than usual.

Messrs. Schmid Brothers of Basel believe that favorable results can be obtained by having the sericin or gum first softened by exposing the raw silk to the action of soap foam, in boxes in the bottom of which is a soapy solution and two coiled pipes by which air and steam are carried inside. The degumming is then completed in the usual way, having the silk hanging on rods mechanically revolving. As it is not in the first phase of the boiling off that the risk of causing splitting is run, we fail to see the usefulness of this innovation that does not appear to have found favor among manufacturers.

In consequence of our tests we believe the following to be the requisites that the degumming appliances must possess:

1. That the fibre be motionless in order that it be not exposed to the least strain during the period in which it is immersed in the hot soapy solution.

2. That inequality of heating be avoided by having the liquor in which is the silk, moderately circulate towards a tank in which the heating is performed.

3. That it be possible to take off at certain given moments the silk that requires a degumming of less duration.

CONCLUSION

We flatter ourselves that the researches summed up and the considerations exposed about the origin of nibs formed on dyed silks, will have made evident:

1. That all the silks in greater or lesser proportion are subject to splitting and that the damages due to the formation of nibs are not peculiar to silks of Italian cultivation.

2. That it is the task of the seed producer to take into consideration in his selections the structure of the fibre and to eliminate those breeds in which the silks are unusually channelled or subject to exfoliation.

3. That silk manufacturers must ascertain, by means of opportune tests—before the purchase of the material—whether the silk selected is adapted to the making of the goods which they are to produce having regard to the imperfections that may be due to the splitting of the fibre.

4. That dyers have the task of adjusting to the changeable resistance of the fibre the treatments to which the latter must be subjected in order to be degummed and dyed; and must avail themselves of the disposition that we have indicated to keep the greatest lustre in the threads and fabrics, without causing splitting of the fibre.

MOULDS OCCURRING ON RAW SILK

Edw. Wallace Pierce, Formerly Chemist, United States Testing Company, Inc., in SILK.

The attention of our laboratory was drawn to the subject of mould in a somewhat peculiar manner. A sample of thrown silk was sent in for a report on some mysterious spots which resembled closely the white specks that are so often seen

on dyed skeins. The microscope showed these to be small masses of silk fibrillae, together with some fibres in the very act of splitting into fibrillae. As the silk had not been dyed nor handled since it had left the throwster, the occurrence of perhaps a dozen of these spots on the end of a few skeins was somewhat of a mystery. Observations of this kind are usually made with only a moderately high magnification so as to take advantage of the larger field and deeper focus of the instrument, but in this instance an observation was made under higher power than usual and the fibres were seen to be covered with bacteria and the spores of moulds.

Before continuing it will be well to say that it was finally found that the spots had been caused by drops of acid and the germs had followed, not caused the damage. Acting on the assumption that we had here a possible cause of fibre splitting, the next step in proper scientific procedure would be to duplicate the effect under known conditions. To accomplish this several skeins of Italian and Japan raw silk were inoculated with the germs and spores by twisting a small portion of the infected portion into the raw silk and placing the skeins under sterile conditions and with a temperature and humidity favorable for incubation.

The best conditions for development were a temperature of sixty degrees F. or less, moisture at the highest possible degree and almost complete absence of light. Under these conditions in a few days the Italian silk developed about the point of inoculation many colonies of mould, but the Japanese resisted for over ten days and never gave such large areas at any time. No attempt was made to follow up the reason for the resistance shown by the Japanese silk, whether due to the presence of antiseptics, harder gum or more waterproof nature on account of the presence of wax or oils, this being left for later investigation.

It had been expected that the prolonged action of the moulds and bacteria under very favorable conditions would have produced very positive effects in the silk. Bacterial action on proteins such as sericin and fibroin would result in liquefaction, the production of putrefactive odors, etc., but no such actions were observed on any of the samples, nor were any colonies of bacteria found. The moulds seemed to dominate the situation and were of two well known species—Aspergillus Niger and Pencillum Glaucum.

A most thorough examination of the fibres with the mould on them and after boiling off failed to disclose the slightest evidence of fibre splitting (fibrillae formation, lousiness). Portions of the original skeins had been retained in their unaltered condition and were now boiled off at the same time as the mouldy skeins and after drying were given the regular tenacity and elasticity test, with the result that not the slightest loss in either factor was to be observed.

The positive effects of mould action are the solution and removal of the sericin, causing a separation of the raw silk thread, which would subject the unprotected fibres to chafing and friction, also a formation of various coloring matters which stain the silk and cannot be easily removed. Red stains are common and these will resist a severe boil in soap; they also cause irregularities in the absorption of tin or dye and lead to streaky dyeings. There is little chance of such things passing by unnoticed for silk has to be very mouldy indeed to be stained and any dyer would be sure to take notice of it.

While engaged in the investigations just noted a raw silk dealer called our attention to some Italian cocoons in which a large number of the chrysalides had died naturally before being heated in the ovens and were characterized by a light weight and chalky appearance. It was suggested that the presence of a number of such diseased cocoons in a reeling basin might infect the whole reeling and give rise to some of the well known defects that we are always trying to explain.

Fig. 102. Thrown Italian silk. The fibres have been subject to a severe chemical action which was followed by the growth of mould. The individual fibres are splitting into fibrillae which average one-tenth the original diameter of the fibres.

A number of the cocoons were opened and a large proportion were found to have the trouble in a greater or less degree. The most pronounced case was dissected and found to be completely disorganized inside the outer shell while on the surface the chalky deposit proved to be the mycelium of a mould or fungus. By means of a differential stain the portions of the insect's tissues were stained red, and the vegetable cells of the mould stained blue, whereby it was seen that the mould had penetrated every part of the body and destroyed the insect. A pure gelatine culture was made of the new mould, which showed it to be a branching thread-like growth with round spores in great abundance. It seemed logical that a mould which would grow in the body of a silkworm would be the cause of

some defects in raw silk, especially as it was capable of liquefying gelatine, so many attempts were made to cause it to develop on Italian raw silk. At present no conditions have been found that will cause this mould to grow on the fibre. The mould in question is the famous Botrytus bassiana which causes the dreaded disease Muscardine or Calcino and is known to be essentially a parasitic fungus. It is usual for the worms to die before they come to the spinning age and we have specimens where the worm had finished his spinning but died from this cause before changing to the chrysalis.

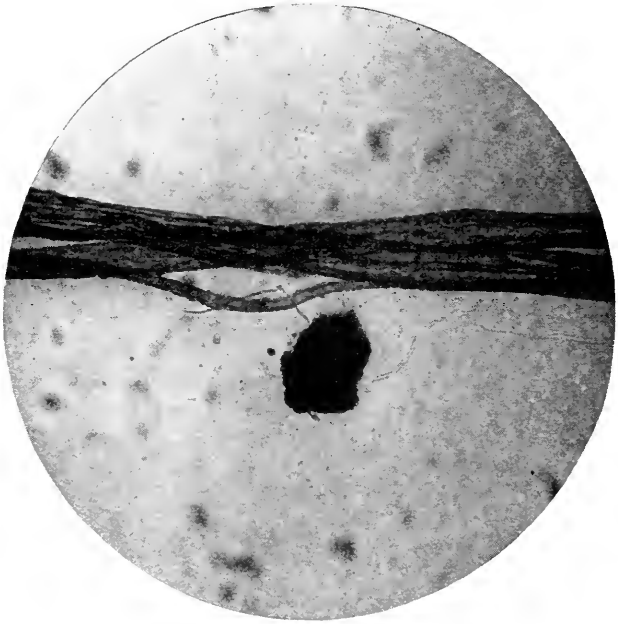


Fig. 103. Mould; Pencillum Glaucum, the thread-like mycelium and the sporangium or head-bearing the spores are seen attached to the silk fibre.

While it had been hoped to prove a clear case against such suspicious characters as the moulds above mentioned, it also shows us that the surface indications and hasty conclusions are not to be trusted. Practically all raw silk, as well as thrown, has on it the spores of moulds and the air about us is full of them. It requires plenty of moisture, a cool temperature and not too much light and the spores will develop; they will develop on a piece of bread, potato, cheese or raw silk, all they require is food and moisture. The ordinary condition of humidity of seventy or less is not enough for mould but when the air becomes saturated and approaches the dew point there is nothing to do but apply the preventative measures of light, fresh air or antiseptics like formaldehyde.

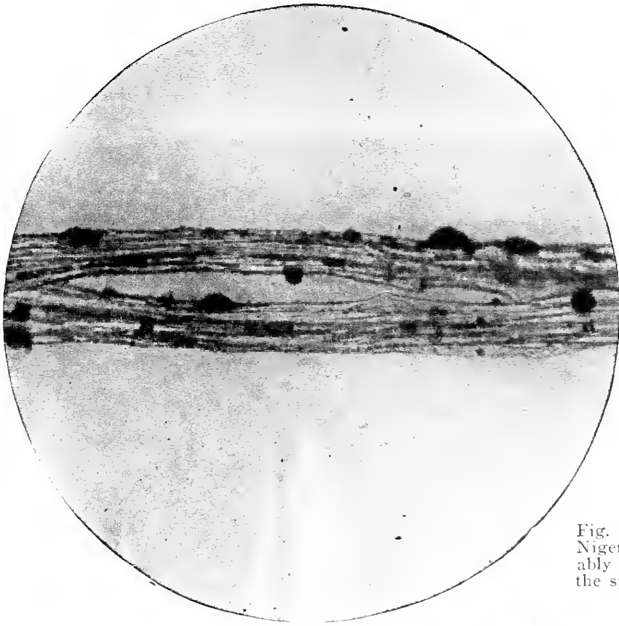


Fig. 104. Mould; Aspergillus Niger, the myscelium is probably dispersed through the gum, the sporangia alone being visible.

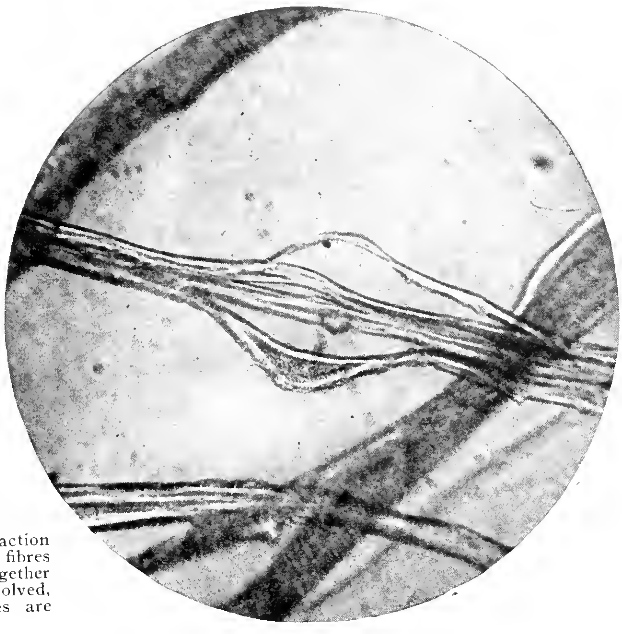


Fig. 105. Effect of mould action on sericin. The individual fibres are no longer cemented together as the gum has been dissolved, while a number of spores are seen attached to fibres.

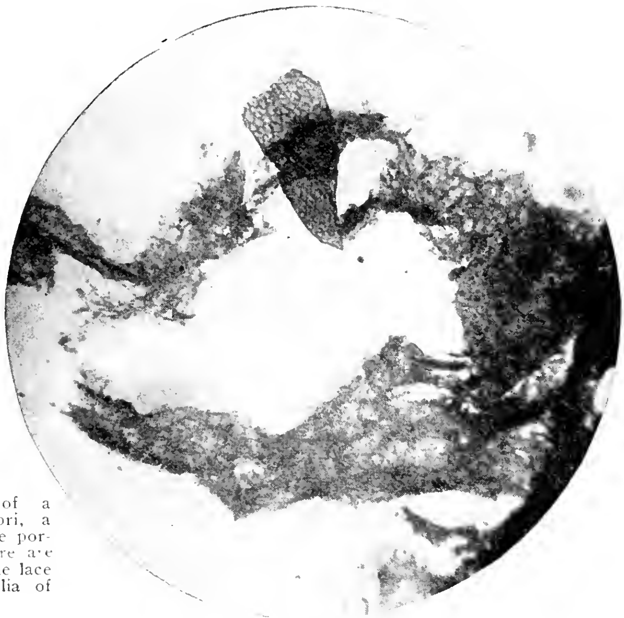


Fig. 106. Fragments of a chrysalis of Bombyx Mori, a victim of Muscardine. The portions showing cell structure are the animal tissues, while the lace like masses are the mycelia of fungus or mould growth.

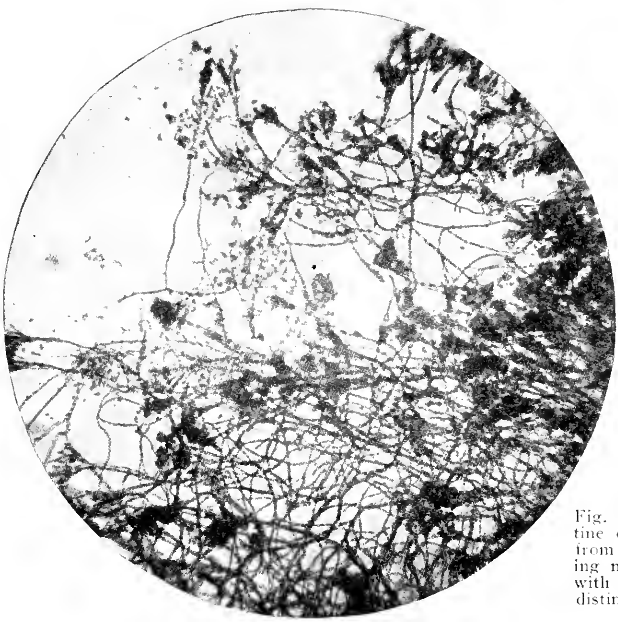


Fig. 107. Pure culture in gelatine of Botrytus Bassiana made from the preceding. The branching mycelium and the sporangia with free spores may be readily distinguished.

APPENDIX—PART V

RULES AND REGULATIONS GOVERNING COMMISSION THROWING AND TO GOVERN BUYER AND SELLER OF RAW SILK IN THE UNITED STATES OF AMERICA. PUBLISHED BY PERMISSION OF THE SILK ASSOCIATION OF AMERICA.

Rules and Regulations governing Commission Throwing of Silk in the United States of America. Approved February 13, 1907. Amended August 14, 1907. Amended September 21, 1921. The Silk Association of America, 354 Fourth Avenue, New York City.

On February 13, 1907, the Commission Throwsters Division of the Association adopted rules and regulations to act as standards in governing transactions in that branch of the industry. These rules have twice been amended to meet changing conditions in the trade, once on August 14, 1907, and again on September 21, 1921, the date of the present edition.

Other divisions of the Association have also adopted sets of rules to further establish and maintain uniformity of commercial usage and practice in matters incidental to the conduct of business transactions. Among these are the raw silk, broad silk, sewing silk and twist, glove silk, spun silk and thrown silk rules.

The general observance throughout the industry of these governing regulations of uniform trade practices has proven a most important factor in reducing controversies.

Rules and Regulations governing Commission Throwing of Silk in the United States of America. Approved by the Board of Managers of The Silk Association of America, February 13, 1907, and amended August 14, 1907, and September 21, 1921:

RESOLVED, That the revised Rules and Regulations to Govern Commission Throwing of Silk have been carefully considered by the Board of Managers of The Silk Association of America and approved by them.

The Board feels justified in adopting them as rules to govern (in the absence of other special agreements) the adjudication of all disputes or claims which may be referred to The Silk Association of America for settlement.

I, the undersigned, Secretary of The Silk Association of America, do hereby certify that the above resolution is a true and accurate transcript from the minutes of the adjourned regular meeting of the Board of Managers of said Association, held in the office of the Association on the 21st day of September, 1921, and recorded in the minutes of said Association.

Witness my hand and the seal of the Association this first day of November, 1921.

FRANK G. BARRY,
Secretary.

RULES

ARTICLE I

General

Section 1. These rules to govern the throwing of silk on commission are promulgated to provide a standard for transactions in this branch of the American silk industry. It is understood that nothing herein shall be construed as waiving the right in individual transactions to make any special or contrary agreement, but that the rules shall govern in cases where they are specified, or where no special or specific contract exists.

Section 2. Raw silk is the single thread as reeled from the cocoons. It is understood to be a continuous thread from beginning to end of the skein and that the skeins in general conform in weight, circumference, and lacing to specification for the American Standard Skein, as issued and approved by The Silk Association of America.

Section 3. All official tests are to be those performed in the Testing Houses of the United States Testing Company, Inc. The expression "Testing House" shall be construed to mean the Testing Houses of the United States Testing Company, Inc.

Section 4. Conditioned weight is the absolute dry weight plus eleven per cent., the standard allowance for moisture.

Section 5. Clean fibre as used in the regulations is the difference between one hundred per cent and the boil-off percentage as determined by the standard boil-off test.

ARTICLE II

Transportation, Insurance, etc.

Section 1. The throwster shall pay the transportation charges upon receipt of the raw silk and the owner shall pay the transportation charges whether such delivery is made to the Testing House, dyer, owner's mill or authorized representative.

Section 2. The owner shall be liable for both the raw and thrown silk while in transit and shall provide at his own expense for such insurance as he may desire. It is understood that the valuation placed upon silk in transit shall be the same as the amount of insurance, and the increased transportation charges resulting from such valuation shall be paid by the owner.

Section 3. The throwster shall fully cover all goods by fire insurance and shall be liable for loss or damage due to negligence or fire.

ARTICLE III

Price, Terms, etc.

Section 1. The price for throwing is net cash. The throwster is entitled to payment on account in proportion to his deliveries and on completion of work when held for orders.

Section 2. In case the contract states an agreed allowance for waste, the adjustment shall be reciprocal, i. e., the throwster will pay the owner for excess waste or the owner will pay the throwster for making less than allowable waste.

Section 3. Silk not called for within thirty days after tender of delivery is at the risk of the owner.

ARTICLE IV

Raw Silk

Section 1. The owner shall furnish the throwster a description of the raw silk giving the origin, and market classification, and shall supply the throwster without cost duplicate certificates of all tests made on the raw silk, which could be used in regulating the throwing operations or calculating the clearances. The owner is responsible to the throwster for a proper delivery of the quality of the raw silk agreed upon.

Section 2. **Weight**—The invoice weight of the raw silk shall be the basis for calculating the throwster's invoice and clearance and said invoice weight shall be furnished to the throwster when shipping in the silk.

ARTICLE V

Clearance

Section 1. The loss in throwing is the difference between clean fibre conditioned weight sent, and the clean fibre conditioned weight returned. The percentage waste shall be calculated by multiplying the loss by one hundred and dividing by the clean fibre sent.

Section 2. **Determination of Loss**—In order to establish a claim against a throwster the owner should have two conditioning tests and one boil-off test made upon each five bales of the lot of raw silk, the remaining bales net weighed and the conditioned weight of the lot certified by the United States Testing Company, Inc., furnishing copies of the certificates to the throwster without charge; provided, that by mutual agreement, the net weighings may be waived and the conditioned weight of the lot calculated upon the invoice weight of the raw silk.

In order to complete the basis for establishing a claim, the thrown silk should be returned to the United States Testing Company, Inc., for official sampling. At least two conditioning tests and two boil-off tests should be made on each five bales or cases, the net weight of the remaining bales or cases determined and the conditioned weight certified; provided, that bundles or packages so sent for testing represent the average lot.

Where two or more tests are made upon a lot of the raw or thrown silk, the average shall apply, provided each test represents an equal portion of the lot.

The owner and throwster shall receive certificates of the thrown silk tests, the cost of such tests to be paid by the owner.

Section 3. Boil-off test, in order to be acceptable as part of the basis of claims must be made on at least ten per cent of a shipment, excepting in the case of silks delivered in skeins, when the test must be made on at least twenty per

cent of a shipment, but in either case not less than one complete bale, case or package is to be submitted.

Section 4. Where the price of throwing is based upon an agreed percentage of waste the throwster shall pay the owner at the invoice price of the raw silk for any excess waste which he makes and the owner shall pay the throwster at this price if the loss is less than the agreed allowance for waste.

Where a maximum waste is stipulated, it will be understood that the throwster is chargeable for the excess at the invoice price of the raw silk.

No claims for excess waste of any kind must be allowed by the throwster or made by the owner excepting those based on Testing House tests made upon official samples.

Section 5. The throwster has the right to have check tests made on his own account if he so desires, in which case, the average of the tests will govern adjustments, if any, the cost of such test to be paid for by the throwster.

Section 6. As the percentage of waste permissible necessarily varies with the nature and quality of the silk and is a matter of advance agreement between the throwster and his customer, no claim shall hold in the absence of such advance agreement except in the event of flagrant loss, when the matter shall be submitted to arbitration.

ARTICLE VI

Thrown Silk

Section 1. **Boil-off**—Only such ingredients shall be used in soaking raw silk as will boil-off easily in the ordinary processes of dyeing and only such amounts as shall be necessary for the proper throwing of the silk.

Section 2. **Skeins**—The thrown silk skeins shall be Grant reeled to the specified length within the limits of variation authorized by the regulations.

Section 3. In the absence of any stated length of skeins the following will apply:

2-thread Organzine	20,000 yards
3-thread Organzine	10,000 yards
2-thread Tram	15,000 yards
3-thread Tram	10,000 yards
4-thread Tram	7,500 yards
5-thread Tram	5,000 yards

The above lengths will apply on thrown silk made 13/15 and/or 14/16 denier, European, Japan, Canton and China Filatures silks only. On all other grades of thrown silk delivered in skeins, the length is optional with the throwster unless stipulated in contract.

Section 4. An average variation of five per cent shall be allowed from the number of yards per skein, as ordered for thrown silk. The minimum number of test skeins is twenty. The procedure is similar to that for sizing silk, Conditioning House rules to apply.

Section 5. No claims for wrong yardage shall be made by owner or allowed by throwster unless based on Testing House tests.

Section 6. The throwster has the right to have check tests made on his own account if he so desires, in which case, the average yardage of the tests will govern adjustments, if any, the throwster to pay the cost of such tests.

Section 7. **Twist**—In the absence of any twist stipulations, the following turns per inch shall govern thrown silks made from 13/15 and/or 14/16 denier raw silk:

2-thread Organzine 16 first time, 14 second time.

3-thread Organzine 16 first time, 12 second time.

Tram 2½ to 3.

2-thread Georgette Crepe 65 to 70.

Ordinary Crepes 60 to 65.

In the case of all other classes of thrown silk, the twist must be stipulated in contract.

Section 8. The variation of the average twist in turns per inch over or below the average of twist stipulated in contract must not exceed twenty per cent on twist under five turns per inch and ten per cent on twist over five turns per inch.

At least ten per cent of a shipment must be sent to the Testing House for twist test, but not less than one complete bale, case or package to permit of proper official sampling.

No claims for wrong twist of any kind shall be allowed by the throwster excepting those based on Testing House Tests.

Section 9. The throwster has the right to have check tests made on his own account, if he so desires, in which case, the average twist of the tests will govern adjustments, if any, the cost of such test to be paid for by the throwster.

ARTICLE VII

Arbitration

Section 1. All disputes, upon request of either party, must be submitted to arbitration before a Committee composed of three disinterested persons, one to be nominated by each party, and the two so nominated to select a third. The arbitration shall be governed by the laws of the State of New York in conjunction with the arbitration procedure of The Silk Association of America and the arbitrators shall be approved by the Arbitration Committee of said Association.

Raw Silk Rules and Regulations To Govern Transactions Between Buyers and Sellers in the United States of America

Approved by the Board of Managers of The Silk Association of America, May 22, 1908, and amended August 9, 1911, and March 23, 1921.

RESOLVED, That the amended Raw Silk Rules and Regulations to govern transactions between Buyers and Sellers in the Raw Silk Market have been carefully considered by the Board of Managers of The Silk Association of America and approved by them.

The Board feels justified in adopting them as rules to govern (in the absence of other special agreements), the adjudication of all disputes or claims which may be referred to The Silk Association of America for settlement.

I, the undersigned, Secretary of The Silk Association of America, do hereby certify that the above resolution is a true and accurate transcript from the minutes of the regular meeting of the Board of Managers of said Association, held in the office of the Association on the 23rd day of March, 1921, and recorded in the minutes of said Association.

Witness my hand and the seal of the Association this 23rd day of March, 1921.

RAMSAY PEUGNET,
Secretary.

Note: Nothing in the following rules shall be construed as waiving the right in individual transactions to make any special contrary agreement, but the rules shall govern in cases where no such special contract exists.

Sales of Specified or Identifiable Lots of Silk from stock, or to arrive, for prompt or future delivery (as for instance, of a lot giving marks and numbers, or a specified lot of a specified chop or grade, or in any other manner identifiable and distinct from other silks) are cancelled (unless contract calls for replacement) by destruction of such silks by fire, marine disaster, war or insurrection, wherever occurring, or through other causes beyond the control of Seller, prior to delivery dates as called for by contract, or by the insolvency of reeler, or by damage to, or destruction of, the producing factory prior to delivery by the reeler.

Note: The Buyer may protect himself by taking out additional marine and/or fire insurance.

Sales of an Unspecified Lot of a Given Grade, Class and Size of Silk (as for instance, a sale of 100 bales Japan Filatures No. 1 at a given price and delivery) cannot be voided except by mutual consent of Buyer and Seller. Delay in actual transit, damage to, or destruction of an unspecified lot of silk, or non-delivery due to the existence of other causes beyond the control of Seller, where a similar lot is not obtainable on the New York market, give the Seller a reasonable period (to be determined by arbitration in case of dispute) in which to deliver or replace.

Deliveries. Sales for delivery on a given date, demand delivery or readiness for delivery on the date specified.

Sales for delivery on arrival on or about a given date, give Seller the right of delivery fifteen days earlier or later than the date specified.

Sales for delivery within a given period, give Seller the right of delivery at any time within the period specified.

Where more than one month is named without other specification, delivery is understood as approximately equal portions during each month.

Seller should notify Buyer of readiness to deliver in accordance with contract terms of delivery, and Buyer is under equal obligation to call for silk when due him, but inadvertent failure of either party to tender or call for delivery shall not void contract where readiness to deliver can be proved.

Delivery by Seller to common carrier or agent of Buyer, in compliance with oral or written instructions of Buyer, or party ordering shipment, is at the risk of said Buyer, or party ordering shipment.

Shipments From Abroad. Sales for shipment on or before a given date, demand shipment on or before the date specified.

Sales for shipment on or about a given date, give Seller the right of shipment fifteen days earlier or later than the date specified.

Sales for shipment within a given period, give Seller the right of shipment at any time within the period specified.

Date of bill of lading shall be construed as giving date of shipment.

Duties And Taxes. Unless otherwise stated, all export duties, import duties and/or taxes in force at date of contract, are included in the contract price. All duties or taxes, or any change in duties or taxes, put into force after date of contract, and in force at contract date of delivery, shall be added to, or deducted from the contract price.

Deferred Deliveries (except by request of Seller) if billed but not shipped, or not billed because of Buyer's request, or when Seller delays shipment because Buyer's credit line is not open, are at the risk of Buyer, who shall pay interest, storage and fire insurance. Seller shall exercise due care and diligence in the storing, handling and insuring of such silk, shall insure it at market value as property sold but not delivered, but shall not be liable for any other matter or thing occurring during the period of the deferred delivery. Total or partial loss by fire shall constitute a good delivery of such silks destroyed or damaged, and the amount owing Seller shall thereupon become due and payable in accordance with terms of contract, but Seller shall credit or refund Buyer with whatever amount may be received from the underwriters on silk so destroyed or damaged. It shall be the duty of the Seller to diligently enforce the collection of any claim covered by the policies of fire insurance, and expenses incurred in so doing shall be deducted from the amount recovered.

Weights. Actual Weight and Tare is weight taken at the time of delivery, or billing date (if delivery is deferred), less actual tare of bags, papers and strings.

Invoice Weight is net weight as invoiced by Seller or Seller's agent at time of original shipment from primary market.

Upon request of Buyer, Seller shall submit to the Secretary of The Silk Association of America his data showing weights forming basis of billing.

Conditioned Weight of silk is the absolute dry weight plus eleven per cent.

To ascertain conditioned weight of a lot of Asiatic silks, at least two bales out of every five (or less) bales of a lot shall be tested at the United States Testing Company, Inc. The average of all tests must be accepted as the basis for the entire lot, and expense of conditioning divided equally between Buyer and Seller.

Japan Silks, China Filatures, Canton Filatures, Tussah Filatures, Tsatlee Rereels, Haining Rereels, Native China Yellow Rereels and other similar silks

are sold invoice weight, or actual weight, or (by special agreement) conditioned weight.

Note: Canton Filatures are customarily sold invoice weight.

Disputes over actual and/or invoice weight must be adjusted between Buyer and Seller on the basis of conditioned weight plus two per cent for Japan Silks, China Filatures, Canton Filatures and Tussah Filatures, and plus two and one-half per cent for Tsatlee Rereels, Haining Rereels, Native China Yellow Rereels and other similar silks.

(The basis of conditioned weight plus two per cent. for Japan Silks is continued temporarily pending final adoption of the basis of conditioned weight, which has been accepted in principle.)

European Silks are sold conditioned weight, and European Conditioning House tests must be accepted, unless Buyer chooses, at his own expense, to have the silk reconditioned in New York. Should the result be one-third of one per cent less than European conditioned weights, Seller must accept the New York conditioned weights and pay costs of the reconditioning; each bale to be treated individually.

Bale Weights. A contract requires the delivery of the number of bales specified, and weight of the bales shall not vary on the average more than five per cent from the following usual bale weights:

European	220.46	pounds net
Japans	132.276	pounds net
Chinas	133 1/3	pounds net
Tussahs	135	pounds net
Cantons	106 2/3	pounds net

Variation in weight beyond the allowed five per cent shall not be cause for cancellation of contract, but may be adjusted with Seller at market rates at time of delivery.

Adulteration. Tsatlee Rereels and Haining Rereels are guaranteed by Seller not to lose more than twenty-two per cent by boil-off at the United States Testing Company, Inc. Szechuen Yellow Rereels shall not boil off more than twenty-four per cent and Shantung Yellow Rereels shall not boil off more than twenty-six per cent. Buyer and Seller may have as many tests made by the United States Testing Company, Inc., as they see fit, at their own expense, and the average of all such tests shall govern.

Variation of Size. The average size under contract shall not vary more than given below for different classes and grades of silk. In case of dispute, Buyer and Seller shall arrange to have sizing tests made at the United States Testing Company, Inc., computed on the conditioned weight of the sizing skeins. Such tests are limited to five per bale and their average shall determine the size of the silk in the bale. For Asiatics, excepting China, Steam Filatures First Category and Japan Filatures Double Extra Crack, the average of all bales of a lot shall determine the average of the lot, and if more than one-third of the bales in each individual lot are of wrong size, such entire lot may be rejected; otherwise, only the incorrect bales may be rejected. For European Silks, China Steam Filatures First Category and Japan Filatures Double Extra

Crack, bales are treated individually, and only the incorrect bales of the lot may be rejected. Test skeins must be drawn from the bales by the United States Testing Company, Inc., and the total expense of such tests borne by the losing party.

European Silks. European Conditioning House sizing tickets shall be accepted, unless demonstrated to be wrong by the United States Testing Company, Inc., whose findings shall be final. Extra Classical to No. 1, inclusive, 10/12 and finer, shall not vary more than three-eighths denier either way from the average given on each and every bale.

11/13 to 15/17—½ denier either way is allowed.
16/18 to 19/21—¾ denier either way is allowed.
20/22 to 24/26—⅞ denier either way is allowed.
25/27 to 28/30—1 denier either way is allowed.

Coarser sizes, variation by agreement.

Japans. Seller's sizing tests, or Yokohama Conditioning House sizing tickets shall be accepted, unless demonstrated to be wrong by the United States Testing Company, Inc., whose findings shall be final.

Filatures Double Extra Crack in all sizes are governed by the same rule as European silks. This rule as it applies to sizes 16/18 denier and coarser becomes operative only on silks contracted for delivery on and after August 1, 1921.

Filatures Double Extra B to No. 1-1½, inclusive, Rereels Extra to No. 1-1½, inclusive, and Best Extra Kakedas, 14/16 and finer, shall not vary more than ½ denier either way for the lot, and 1 denier for each bale, from the average given.

Filatures and Rereels No. 1½ to No. 2, inclusive, and Kakedas Extra to No. 1, inclusive, 14/18 and finer, shall not vary more than 1 denier either way for the lot, and 1½ deniers for each bale, from the average given. Lower Grades carry no guarantee of size.

Size 16/18 and Coarser in Filatures No. 1 and Higher Grades up to and including Double Extra B, shall not vary more than the European silks allowance for the lot, and ½ denier additional for each bale, from the average given. Coarse sizes below No. 1 carry no guarantee of size.

China Filatures. Seller's sizing tests shall be accepted, unless demonstrated to be wrong by the United States Testing Company, Inc., whose findings shall be final.

Steam Filatures of the First Category shall not vary more than the following limitations either way from the average given on each and every bale:

10/12 denier and finer—⅜ denier either way is allowed.
11/13 to 15/17 denier—½ denier either way is allowed.
16/18 to 19/21 denier—¾ denier either way is allowed.
20/22 to 24/26 denier—⅞ denier either way is allowed.
25/27 to 28/30 denier— 1 denier either way is allowed.

Coarser sizes, variation by agreement.

Steam Filatures of the Second and Third Categories shall not vary more than the above table for the lot, and an additional ½ denier for each bale, from the average given. Coarser sizes, variation by agreement.

Steam Filatures of the Fourth Category and Native China Filatures shall not vary more than the following limitations either way from the average given for the lot, and an additional ½ denier for each bale:

10/12 denier and finer— ⅝ denier either way is allowed.
11/13 to 15/17 denier— ¾ denier either way is allowed.
16/18 to 19/21 denier—1 denier either way is allowed.
20/22 to 24/26 denier—1⅛ denier either way is allowed.
25/27 to 28/30 denier—1¼ denier either way is allowed.

Coarser sizes, variation by agreement.

The rule governing size of China Filatures applies to the first and second choice of the filatures. The third choice is to be governed by the table for the category next below the rating of the filature.

Tsatlee Rereels, Haining Rereels, Native China Yellow Rereels, Tussahs, and other similar silks, carry no guarantee of size.

Canton Filatures. Seller's sizing tests shall be accepted, unless demonstrated to be wrong by the United States Testing Company, Inc., whose findings shall be final. Double Extra 14/16 and finer shall not vary more than ¾ denier either way for the lot, and 1¼ deniers for each bale from the average given. 16/18 to 28/30 shall not vary more than 1 denier either way for the lot and 1½ deniers for each bale, from the average given. 16/20 to 28/32 shall not vary more than 1½ deniers either way for the lot, and 2 deniers for each bale, from the average given.

Canton Silks below the grade of Double Extra B carry no guarantee of size.

Rejections and Replacements. Any bales or lots rejected for proper cause must be replaced by Seller and accepted by Buyer within 15 days of date upon which rejection is agreed to by Seller or established by arbitration (unless other adjustment is ordered by the arbitrators), and where the replacement is not accepted by Buyer or arbitration, the arbitrators may order another replacement or make cash adjustment. Rejected bales must be returned in merchantable condition. Where a lot of contract brand or quality and size is not obtainable on the New York market, the question shall be adjusted by arbitration. In case of a specified uninspected lot on a primary market—of which all or a portion shall prove upon inspection not of the stipulated quality and/or size—Seller must immediately notify Buyer, who shall have the option of cancelling such incorrect portion of the contract, or of instructing Seller to accept it with any allowance that he may be able to collect, or of giving the necessary time for replacement.

Claims for Difference in Quality and/or Size. Buyer is under obligation to examine and test silk received or tendered for delivery under contract, and promptly pass upon its quality and size as raw silk in the bale. This can be determined by testing sample of skeins of the lot or one entire bale. Buyer must then accept, or immediately notify Seller of intention to reject the balance

of the lot. All claims must be made within fifteen days after delivery, or within thirty days if billed but not delivered, after which periods no claim shall be admissible unless false packing or fraud can be shown. In no case can the Seller be held as guaranteeing the working of the silk or its suitability to produce certain results, unless by special agreement.

Brokerage is payable by the Seller and, when not otherwise arranged, shall be ½ per cent of the gross amount of the sale, except that it shall be 1 per cent on low grade silks, such as Tussahs, Water-reel and Doppioni. Broker's commission is earned when sale is made, and it is due on date of actual delivery of silk, or on repudiation or cancellation of sale with or without indemnity. Brokerage is not due on sales cancelled from causes beyond the control of Seller as provided in these rules.

Selling Terms. The recognized rate of discount in the silk trade is six per cent per annum, when not otherwise agreed.

Prices of silk, when not otherwise stated, imply:

4 months' basis for Asiatics,
60 days' basis for Europeans,
payable in United States currency, free of exchange in New York.

All sales of raw silk (except where cash terms are agreed upon, or transactions calling for the drawing of foreign draft on the Buyer or his Bankers) shall be on the terms of Trade Acceptance, settlement within thirty days from date of bill.

4 Months' Basis, settlement within 30 days by Cash or Trade Acceptance, gives the Buyer the right to deduct two per cent from the face of the invoice if payment is made within ten days; otherwise, he must give four months' Trade Acceptance, or pay cash less the discount for the unexpired portion of the four months.

The same applies to shorter terms, viz.:

90 days less ½ per cent
60 days less 1 per cent

That is, in each case settlement must be made within thirty days by cash, or by Trade Acceptance for the time stated on the invoice, for the face amount less the respective discounts of ½ per cent or 1 per cent, as the case may be.

Where sales are made on net terms shorter than 4 months' basis, such as:

90 days' basis
60 days' basis

settlement is likewise to be made for the face amount of bill within thirty days of its date, by paying cash less the discount for the unexpired portion of the stated time, or by giving a Trade Acceptance for the time called for by the bill.

Where Seller reserves the right to exact Trade Acceptance without giving the privilege of discount, the terms should read:

4 months' Trade Acceptance (or 90 days' Trade Acceptance, or 60 days' Trade Acceptance, as the case may be) not discountable.

Sales on terms of 10 days, require payment within that period, less the stipulated discount, if any. Cash sales require immediate payment of the bill.

Sales on New York terms, require delivery to carrier or Buyer's warehouse within the limits of New York City (Borough of Manhattan) unless otherwise stipulated.

Each delivery shall be considered as a separate sale.

The undelivered part of a contract may be cancelled, by proper notification by Seller, for any default in payment by Buyer, either in respect to that or any other contract, Seller being entitled to, or responsible for, the difference between the contracted and market price at date of cancellation.

Seller may at any time alter or suspend credit when, in his opinion, the financial condition of the Buyer warrants it. In such case, cash payment or satisfactory security may be required by Seller before shipment.

Sales calling for Banker's Credits, require the Buyer to immediately furnish Letters of Credit satisfactory to the Seller at the usance agreed upon in the transaction, and the Seller's failure to demand Letter of Credit shall not be cause for voiding the contract. For such sales and for sales made upon the basis of foreign drafts direct upon the Buyer, the Seller takes no responsibility for arrival, damage, loss or pilferage en route, and the Buyer must, at his own expense and risk, attend to the entry, cartage and storage upon arrival.

F. O. B.—Free on Board, is the Shipper's invoice cost of the silk placed on board ship at port of original export. Buyer must provide and pay for marine insurance and freight.

C. & F.—Cost and Freight, is the Shipper's invoice cost including freight to agreed point of delivery.

C. I. F.—Cost, Insurance and Freight, is the Shippers' invoice cost including freight and marine insurance to agreed point of delivery.

Adjustment and Arbitration. Disputes between Seller and Buyer arising from contracts based on these rules may be submitted to the Committee on Adjustments of The Silk Association of America. If an adjustment cannot thus be effected the matter must, upon application of either party, be submitted to an Arbitration Committee of The Silk Association of America, for arbitration in accordance with the rules of such Association. The award shall be final and binding upon both parties.

Where the parties are unable to agree upon the form of the statement of the controversy to be embodied in the submission, that matter shall be determined in advance by the Committee on Arbitration and the determination of the Committee accepted by the parties.

APPENDIX—PART VI

REPORTS OF THE RAW SILK CLASSIFICATION COMMITTEE ON STANDARD TESTS FOR RAW SILK, TENTATIVE STANDARD TESTS FOR RAW SILK, TENTATIVE CLASSIFICATION, AMERICAN STANDARD SILK SKEIN

The Reports of the Raw Silk Classification Committee were submitted to the Board of Managers of The Silk Association of America at their meeting on September 21, 1921, and received as follows.

RESOLVED, That the Board of Managers of The Silk Association of America in meeting assembled September 21, 1921, do hereby receive the three reports of the Raw Silk Classification Committee of the Association on methods of testing, their interpretation and application, as follows:

I. Standard and Tentative Standard Tests.
II. Tentative Classification.
III. Specifications for the Standard American Silk Skein.

and it is further

RESOLVED, That the Secretary of the Association be directed to have these reports printed and distributed.

I, the undersigned, Secretary of The Silk Association of America, do hereby certify that the above resolutions are the true and accurate transcripts from the minutes of the adjourned meeting of the regular meeting of the Board of Managers of said Association held in the office of the Association on the twenty-first day of September, 1921, and recorded in the minutes of said Association.

Witness my hand and the seal of the Association this twenty-fifth day of January, 1922.

FRANK G. BARRY,
Secretary.

Letter of Transmittal as Submitted by the Raw Silk Classification Committee

To the Board of Managers of The Silk Association of America:

Your Raw Silk Classification Committee, designated and organized during the Spring of 1915, following the Essay Competition and award of prizes in 1914, wishes to submit the following reports and recommendations.

The Committee held its first meeting June 29, 1915, and began a careful study of the problem before it. A survey was made of laboratories engaged in the testing of silk and advice and assistance was sought from the technical men available in the New York market.

The meetings during 1915 and 1916 revealed a very wide divergence of opinion within the Committee regarding the essentials of a system of classification. Aside from the European methods of testing and inspection, numerous special tests were being used. Naturally, each member considered his methods the most satisfactory and was quite unwilling to discard them without definite evidence to show something better. The intervening years have been devoted to collecting, compiling and interpreting data, and meetings have been held to discuss progress.

The Committee is pleased to report that its work has reached a point where it seems advisable to submit recommendations on:

Standard Tests for Raw Silk

Tentative Standard Tests for Raw Silk

Tentative Classification for Italian, Japanese and Chinese Steam Filature (Shanghai) Raw Silk

Specifications for American Standard Silk Skein

The Standard Tests for raw silk recommended are the Winding Test, the Sizing Test and the American Sizing Test and are sufficiently in conformity with the present testing practice so as not to be a decided change.

The Tentative Standard Tests for raw silk are recommended as tentative standards because they are still in the state of development, but are sufficiently advanced to represent the best current laboratory practice. They are not involved in the Rules and Regulations Governing Transactions in Raw Silk and, therefore, do not affect sales contracts under the rules of the Silk Association. These Tentative Standard Tests are:

The Gage Test
The Serimeter Test
The Serigraph Test
The Cohesion Test

The Tentative Classification proposes four grades of silk as sufficient to meet the present needs. The specifications in each grade are the minimum requirements which must be met for that grade. Raw silks which fail to meet the requirements of the fourth or lowest grade will constitute a group of low quality silk not requiring classification.

The values specified for the properties in each group are based upon large numbers of tests made in the laboratories represented on the Raw Silk Classification Committee, compiled and compared by the staff of the United States Testing Company, Inc., and made sufficiently broad so as to be well within the practical attainment of any well managed filature.

The Tentative Classification, as recommended, represents the best composite opinion that can be secured in the Committee at the present time. It has received the unanimous approval and support of the individual members and is recommended for approval with the understanding that as the knowledge of the Committee upon testing of silk and the application of test results increases and expands, this Classification may be amended and amplified.

The American Standard Silk Skein is based fundamentally upon the present specification and does not differ from it in any vital particulars, but so completely revises both the form and subject matter as to constitute a new specification and should be adopted in that manner rather than as an amendment to the present one.

Increased emphasis has been laid upon the proper diamond formation, the elimination of gum spots, the skein weights for various denier and the proper lacing both as to manner of lacing and material used. Special figures illustrating these subjects have been prepared, and it is believed that they will be more easily understood than in the present specification.

Three appendices are added and are intended to assist those striving to produce the American Standard Skein.

Appendix A contains the Winding Test and a tentative method of classifying Italian, Japanese and Chinese (Shanghai) Steam Filature Raw Silk as to its winding quality.

Appendices B and C describe the mechanical essentials in design of reeling and re-reeling machines for making the Grant reeled skein and furnish diagrams from which very simple and inexpensive machines may be constructed in localities possessing limited machine shop facilities and skill.

Respectfully submitted,

Raw Silk Classification Committee.

D. E. Douty, Chairman
Albert Bosshard
W. F. Edwards
John H. Jewett
Charles Muller
George A. Post
Frederick Schmutz
Warren P. Seem

PART ONE

STANDARD TESTS FOR RAW SILK

ARTICLE I.

General

Section 1.—**Object.** These specifications for standard tests for raw silk are promulgated by The Silk Association of America for the purpose of standardizing the official methods of testing silk in the United States, in order to facilitate the transactions between buyers and sellers of silk, and to furnish the producers of raw silk on the primary markets accurate information upon the methods by which the characteristics of their products are to be determined by the American consumers. While the test methods herein described consitute the standard tests, they are not to be construed as waiving the right in individual cases to make any or all of them in any other manner, or to make such other tests as may be desired.

They shall apply and govern as the methods to be used for official tests by the United States Testing Company, Inc., relating to contracts in which they are specified, under the Rules and Regulations of The Silk Association of America, and in other cases where no special or specific methods are specified.

Section 2.—**Definitions.** Raw silk is the single thread as reeled from cocoons and is understood to be a continuous thread from beginning to end of skein. The skeins in general conform in weight, circumference and lacing to the specifications for the American Standard Silk Skein described in Part IV of this report, as issued by The Silk Association of America.

Standard Condition. Where the expression "standard condition" is used in these specifications, it shall be understood to mean the condition of the silk when it contains eleven per cent of its dry weight, of moisture.

Standard Atmosphere. The expression "standard atmosphere" shall be understood to mean such condition of the air that silk placed in it will, within a reasonable period, assume a standard condition.

Section 3.—**Sampling.** It is important in testing by means of samples drawn from the merchandise, that the samples should be so selected as to be representative of the merchandise and that a sufficient proportion of the lot should be sampled to be representative of the entire lot to which the tests are to apply.

The amount of sample and the number of samples herein specified are understood to be the mimimum which can be considered as representative and which shall constitute an official sample in size and distribution.

Sample for Test. The sample for a test shall consist of at least ten average original skeins, selected at random from different parts of a bale, not more than one skein to be drawn from any one book or bundle, and only skeins from a single bale to be included in any single test. Test samples for two or more different kinds of tests may be taken from the original ten skeins.

Sample from Lot. If the results of test are to represent and be applied to a lot, at least two tests must be made upon every five bales of the lot, one from each of two bales selected at random.

ARTICLE II.

Winding Test

Section 1.—**Object.** The Winding Test is intended to show the manner in which the raw silk thread will pass through the winding operation.

Section 2.—**Sample.** The sample for the test and the sampling of the lot is as specified in Article I, Section 3. Only original, intact skeins, drawn fresh from the bale, shall be used.

Section 3.—**Apparatus.** The winding frame upon which the test is made shall run at a uniform speed and be capable of adjustment to the following average thread speeds, 110, 137½, 165 meters [120, 150, 180 yards] per minute.

Standard Bobbin. To insure a uniform tension and speed, the bobbin should have the following dimensions (Figure 1-108):

Diameter of head, 50 millimeters (2 inches)
Diameter of drum, 44 millimeters (1¾ inches)
Length between heads, 75 millimeters (3 inches)

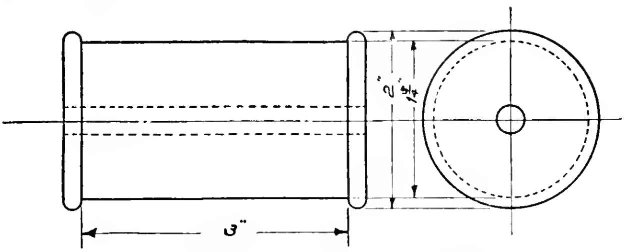


Fig. 1-108. BOBBIN FOR STANDARD WINDING TEST.

The bobbins should be constructed so as to be light, well-balanced and smooth, and should revolve smoothly.

Swifts. The swifts (tavelle) used in the test should be self-centering geared pin hub swifts without weights, or twelve stick, pin hub swifts without weights. (Figure 2.)

Section 4.—**Skeins.** The sample skeins shall be put on the swifts with care to insure that each skein is in good condition. The degree of the gum spots, if any are present, should be recorded. Five skeins shall be wound from the top and five from the bottom.

Speed of Winding. The average thread speed of winding shall be adjusted according to the average size of the raw silk and shall be regulated as nearly as possible to the following speeds.:

Below 13 denier	110 meters	(120 yards) per minute
13 denier to 17 denier ..	137.5 meters	(150 yards) per minute
Above 17 denier	165 meters	(180 yards) per minute

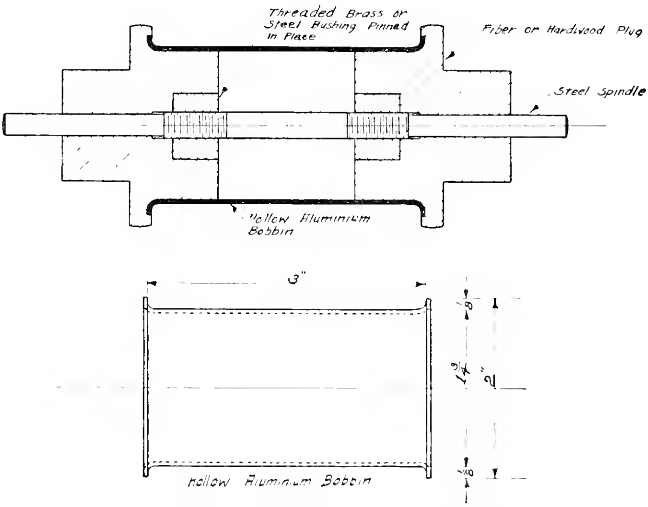
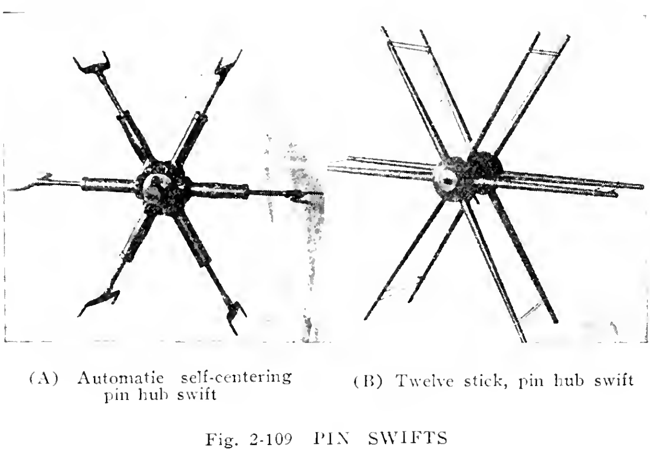


Fig. 1 A. SUGGESTED HOLLOW ALUMINUM BOBBIN FOR WINDING TEST

Note—The bobbin is to be spun from seamless, light weight aluminum tubing one and three quarters inches O. D. The fibre or hardwood plugs are to be interchangeable and the steel spindle is to be universal so as to be used in either direction.

For single end drive the hub is to be removed from one plug. The design of the removable plugs and spindle may be modified in any way to reduce cost of manufacture.

Trays holding ten bobbins should be made from light wood and in such a form as to stack without injuring the bobbins and provided with a clip for a card bearing the number of the test, the weight of the ten bobbins empty, the weight filled, etc.



(A) Automatic self-centering pin hub swift

(B) Twelve stick, pin hub swift

Fig. 2-109 PIN SWIFTS

The maximum thread speed of winding at the completion of the test shall not exceed the following:

Below 13 denier ....130 meters (140 yards) per minute
13 denier to 17 denier ...155 meters (170 yards) per minute
Above 17 denier ....180 meters (200 yards) per minute

Winding. During the winding test, the winding laboratory shall be maintained at as nearly a standard atmosphere as possible.

First Period. The skeins should be wound onto spare bobbins for fifteen minutes. They should then be inspected to determine if any are in bad condition due to damage, mishandling or improper putting on. If any skeins are found to be in bad condition due to causes other than poor reeling, they shall, provided they do not exceed two in number, be omitted from the test which shall be completed on the remaining skeins. If they do exceed two in number, additional samples shall be drawn and replace the damaged ones.

Second Period. The spare bobbins shall then be replaced by standard bobbins and the winding continued until the standard bobbin for each skein is filled flush with the heads, care being taken to insure proper traverse to wind a smooth, compact bobbin.

Note—The second period should require about one hour for a fourteen denier raw silk and yield about 10,000 yards from each skein, or 100,000 yards for the test. Other sizes will require proportionately other yardages to fill the standard bobbins.

Section 5.—**Record. First Period.** A separate record (Figure 3) shall be kept of the number of breaks occurring in the first fifteen minutes and special note made of excessive breaks in any particular skeins, stating the cause.

Second Period. After the inspection of the skeins, a record shall be kept of the breaks and special attention given to any skeins showing an excessive number of breaks.

Weighing. When the bobbins are filled, the raw silk will be rereeled, without waste, into skeins, and placed for at least two hours in a space maintained at a standard atmosphere so that the silk will regain moisture to the standard condition.

The skeins will then be weighed in grams and the number of breaks per 100 grams calculated by proportion. The breaks per 100 grams may be converted into approximate breaks per pound by multiplying by four and one-half.

The breaks per 100 grams may be converted into approximate breaks per 100,000 yards by multiplying by one-tenth of the average size of the silk.

Note—If the suggested Hollow Aluminum Bobbin (Figure 1A) is used, the hubs and spindle can be removed and the silk weighed on the aluminum tube before rewinding into skeins, thus avoiding waste and delay.

Fig. 3-110

LABORATORY RECORD

Winding Test

Test Number........ Order Number........ Date........ Kind......
Marks................ Bale Number............ Chop............
Average Size (S)...............Denier.

TEST

Speed of Winding ....Yards per minute
Condition of Gum Spots ....
First Period: Breaks.............
Remarks ....
Second Period: Time.........Minutes

Skein Numbers		1	2	3	4	5	6	7	8	9	10	Breaks per ten
Breaks	1st ten											
	2nd ten											
	3rd ten											

No. of Skeins Wound........ Weight Wound (W)=........Grams
........(B) Breaks.

Breaks per 100 Grams=B x $\frac{100}{W}$ =......(C) Breaks.

Breaks per Pound=C x 4.5=......Breaks.

Breaks per 100,000 Yards=C x $\frac{S}{10}$ =......Breaks.

Winding Quality (as per Tentative Classification, Appendix B)......
Wound by .... Weighed by ....
Computed by .... Checked by ....

ARTICLE III.

Sizing Test (450 Meter)

Section 1.—**Object.** The Sizing Test is intended to determine the average size, i. e., the weight in deniers of the raw silk thread, per 450 meters. One denier equals five centigrams.

Section 2.—**Apparatus.** The measuring machine for making the 450 meter sizing skeins shall have a reel 112½ centimeters in circumference (400 revolu-

tions equal 450 meters), revolving at a uniform velocity of 300 revolutions per minute; provided with a dial showing the number of revolutions, and equipped with an automatic stop motion to stop the reel abruptly in case the thread breaks and when the skein is complete. (Figure 4.)

The balance for determining the total weight of the skeins shall be capable of being read to five centigrams. (Figure 5.)

The balance for weighing the individual test skeins should be of the quadrant type, graduated in half deniers. (Figure 6.)

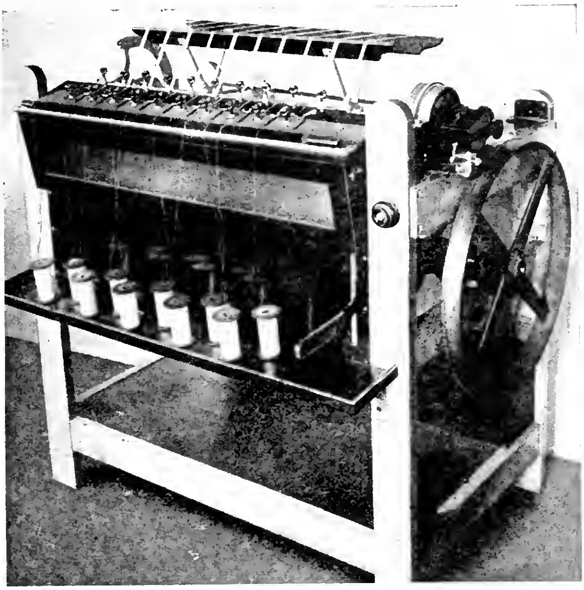


Fig. 4-111 MEASURING MACHINE

Section 3.—**Sample.** The sample for the test and the sampling for the lot shall be taken as specified in Article I, Section 3.

Section 4.—**Test.** From the ten sample skeins, ten bobbins (one from each skein) shall be wound five from the outside and five from the inside. The ten bobbins shall be placed upright on the measuring machine and three test skeins, 450 meters each, reeled from each bobbin, a total of thirty sizing skeins. The sizing test skeins may, if desired, be taken from the bobbins wound in the winding test.

The room in which the reel is located should have temperature and humidity control regulated to maintain a standard atmosphere and the silk should be in

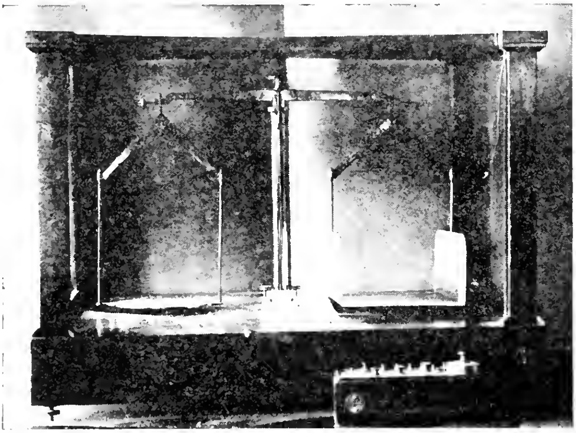


Fig. 5-112 SKEIN BALANCE WITH SPECIAL PAN

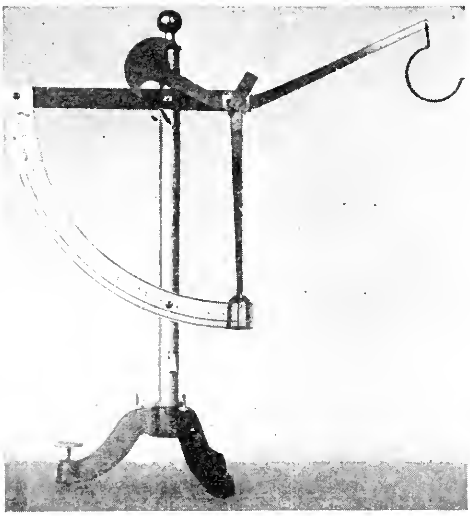


Fig. 6-113. QUADRANT BALANCE

as nearly standard condition as possible at the time of reeling. The tension on the thread should be sufficient to hold it taut without excessive stretching. Care should be exercised to see that no short test skeins are reeled by the stop motion failing to act quickly upon breaking of thread, or long skeins by running over 400 revolutions.

The sizing skeins, which lose moisture during reeling, even in a standard atmosphere, should be allowed to remain in the standard atmosphere for a sufficient time (about one hour) to allow them to return to standard condition and then they should be weighed as follows:

Regular Sizing. If the standard condition assumed by the sizing skeins in the reeling room is sufficiently accurate, the thirty skeins should be weighed together and their total weight expressed in deniers.

Each skein should then be weighed on a quadrant balance to the nearest half denier and the sum of the individual weighings should not differ from the total weight by more than one-half denier.

Fig. 7-114

LABORATORY RECORD

Sizing Test (450 Meter)

Test Number........ Order Number........ Date...... Kind......

Marks .... Bale No. .... Chop ....

Number of sample skeins drawn ....

Number of sizing skeins reeled and weighed ....

TEST

REGULAR SIZE

Denier (D)	Number of Skeins (N)	(D x N)	Number of Skeins (N)	Denier (D)
0				0
0½				0½
1				1
1½				1½
2				2
2½				2½
3				3
3½				3½
4				4
4½				4½
5				5
5½				5½
6				6
6½				6½
7				7
7½				7½
8				8
8½				8½
9				9
9½				9½
Sum of Weights				
Total Weight				
Average Size				

CONDITIONED SIZE

Absolute dry weight of skeins= ....Grams.

....Multiplied by 20=...Denier.

....Plus 11%= ....

Conditioned weight =...Denier.

Average conditioned size =.... Denier.

Observers

Measured by

....

Conditioned weight by..........

Computed by

....

Checked by

....

Note—In the column headed "Denier (D" by placing a 1 or a 2 before the "o" at top the numbers may be made to read anything from "o" to "30."

Conditioned Sizing. If a more accurate average size than the regular sizing is desired, the sizing skeins should, after completion of the regular sizing, be placed together in a conditioning oven, dried to constant weight at 130° C. to 140° C. (266° F. to 284° F.) and weighed in the dry, hot atmosphere.

Section 5.—**Record.** The record should show (Figure 7).

(a) The number of sample skeins drawn
(b) The number of sizing skeins reeled and weighed
(c) The total weight of the test skeins in deniers
(d) The average weight per skein, i. e., the average size in deniers
(e) The weight of the individual skeins arranged in the order of increasing magnitude and the sum of the individual weighings.

Conditioned Sizing. In addition to the record made for the regular sizing, the record of the conditioned sizing should show the total dry weight in deniers; the total conditioned weight in deniers, i. e., the dry weight plus eleven per cent; and the average conditioned weight per skein, i. e., the average conditioned size in deniers.

ARTICLE IV

American Sizing Test (225 Meter)

Section 1.—**Object.** The American Sizing Test is intended to determine the variation in weight, in deniers, of 225 meter lengths of the thread; the average weight in deniers of 225 meters of the thread; and the average size, i. e., the weight in deniers per 450 meters.

Range. The range for a test is the difference in deniers between the weight of the lightest and heaviest 225 meter test skein in the test. The range for a lot is the difference between the lightest and the heaviest test skein in the lot.

Section 2.—**Apparatus.** The measuring machine for making the 225 meter test skeins, the balance for determining their total weight and the balance for weighing the individual skeins, shall be as specified for the Sizing Test (Article III, Section 2).

Section 3.—**Sample.** The sample for the test and sampling for the lot shall be taken as specified in Article I, Section 3.

Section 4.—**Test.** From the ten sample skeins, ten bobbins (one from each skein) shall be wound, five from the outside and five from the inside. The ten bobbins shall be placed upright on the reeling machine and six test skeins, 225 meters each, reeled from each bobbin, a total of sixty test skeins. The test skeins may be taken from the bobbins wound in the winding test, if desired. The room in which the reel is located should have temperature and humidity control regulated to maintain standard atmosphere and the silk should be in as nearly standard condition as possible at the time of reeling. The test skeins, which lose moisture during reeling, even in a standard atmosphere, should be

allowed to remain in the standard atmosphere for a sufficient time (about one hour) to allow them to return to standard condition, and then they should be weighed as follows:

Weighing. The sixty test skeins should be weighed together and their total weight expressed in deniers. Each skein should then be weighed on a quadrant balance to the nearest half denier.

Conditioned Sizing. If the conditioned size is desired, the skeins may then be placed in a drying oven, dried to constant weight at 130° C. to 140° C., (266° F. to 284° F.) and weighed in the dry, hot atmosphere.

Section 5.—**Record.** The record should show (Figure 8):

(a) The number of sample skeins drawn
(b) The number of test skeins wound
(c) The total weight of the test skeins
(d) The average weight of the test skeins
(e) The weight of the individual test skeins, arranged in order of increasing magnitude
(f). The sum of the weight of the individual test skeins
(g) The difference between the weight of the lightest and heaviest test skeins expressed in deniers, i. e., the range.

The average size may be calculated by multiplying the average weight of the test skeins by two, or by dividing the total weight of the sixty skeins by thirty.

Caution—The range found for 225 meter skeins cannot be converted into the "spring" ("ecart") in 450 meter skeins by multiplying by two nor by doubling the weight of the lightest and heaviest 225 meter skein and taking their difference. Such a calculation would assume that the extreme fine and coarse portion trom which the lightest and heaviest 225 meter skeins were reeled, continued for another 225 meters. This is not a safe assumption, for the reason that the "spring" ("ecart") determined by the 450 meter sizing test is always less than double the range found by the 225 meter test upon the same silk.

Figure 115

LABORATORY RECORD

American Sizing Test (225 Meter)

Test Number........ Order Number........ Date........ Kind......

Marks................. Bale Number............ Chop............

Number of sample skeins drawn.............

Number of sizing skeins reeled and weighed........

TEST

REGULAR SIZE

Denier (D)	Number of Skeins (N)	(D x N)	Number of Skeins (N)	Denier (D)
0				0
0½				0½
1				1
1½				1½
2				2
2½				2½
3				3
3½				3½
4				4
4½				4½
5				5
5½				5½
6				6
6½				6½
7				7
7½				7½
8				8
8½				8½
9				9
9½				9½
Sum of Weights				
Total Weight				
Average Size				

CONDITIONED SIZE

Absolute dry weight of skeins= ....Grams.

....Multiplied by 20=....Denier.

....Plus 11%= ....

Conditioned weight=....Denier.

Average conditioned size= .... Denier.

Observers

Measured by

....

Weighed by

....

Conditioned weight by..........

Computed by

....

Checked by

....

Range..........to..........=..........Deniers.

PART TWO

Tentative Standard Tests for Raw Silk

ARTICLE I

Gage Test

Section 1.—**Object.** The Gage Test is intended to measure the reeling defects in raw silk and consists of a determination of the number and kind of defects in a given length of the thread.

Section 2.—**Apparatus.** The Gage (Figure 23) Chapter VI consists of hardened tool steel approximately six and one-half inches long, one inch wide, and one-half inch thick. One narrow side of each piece is ground accurately to a plane, and the two pieces are bolted together so that the plane surfaces form a very narrow V-shaped slit between them. The gage is graduated to read in deniers by determining fixed points at which the width of the V-slit is equal to the calculated diameter of raw silk of a selected denier, and by dividing the distance along the gage into spaces proportional to the diameter of the thread.

Ten gages constitute a set, which is mounted on a reeling machine (Figure 24, Chapter VI) in such a manner as to be adjusted to allow the silk, as it passes through guides from bobbins onto a measuring reel, to run through the gages at its average denier as determined by a sizing test.

Section 3.—**Evenness Defects.** (A) **Weak Threads** (tender or fine) are those which break thirty per cent to fifty per cent below the average strength of the thread.

(B) **Very Weak Threads** (tender or fine) are those which break fifty per cent or more below the average strength of the thread.

(C) **Coarse Threads** are those which catch and break in the gages and of which the strength is thirty per cent to fifty per cent above the average strength of the thread.

(D) **Very Coarse Threads** are those which catch and break in the gages and of which the strength is fifty per cent or more above the average strength of the thread.

Section 4.—**Cleanness Defects.** On account of the unequal importance of the different cleanness defects in the manufacturing and finishing processes and in their effect upon the quality of the finished goods, cleanness defects are divided into two classes, viz.—Major Defects and Minor Defects.

(A) **Major Defects**—(Figures 11, 12, 13, 14, 15.)

(1) **Waste** is a mass of tangled open fibre attached to the raw silk thread. (Figure 11.)

(2) **Slugs** are thickened places several times the diameter of the thread, of three millimeters (one-eighth inch) or over in length. (Figure 12.)

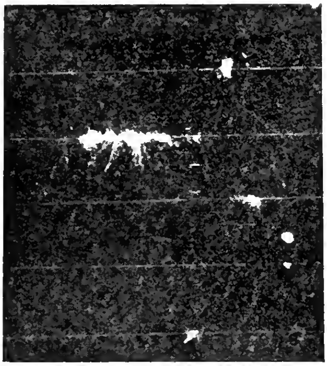


Fig. 11. WASTE

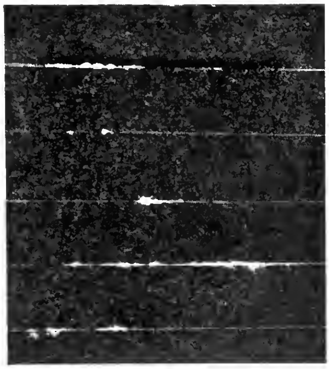


Fig. 12. SLUGS

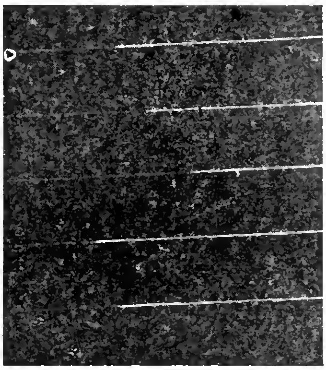


Fig. 13. BAD CASTS

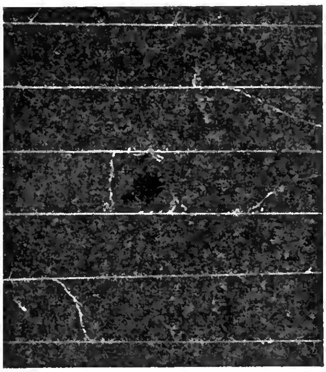


Fig. 14. SPLIT THREADS

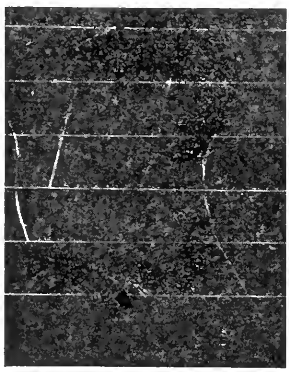


Fig. 15. VERY LONG KNOTS

Figs. 11-15—118

MAJOR DEFECTS

(3) **Bad Casts** are abruptly thickened places on the threads due to the cocoon filament not being properly attached to the thread. (Figure 13.)

(4) **Split Threads** are large loops, loose ends, or open places on the thread where one or more cocoon filaments are separated from the thread. (Figure 14.)

(5) **Very Long Knots** are knots which have loose ends exceeding two and one-half centimeters (one inch) in length. (Figure 15.)

(B) **Minor Defects**—(Figures 16, 17, 18, 19, 20.)

(1) **Corkscrews** are places on the thread where one or more cocoon filaments are longer than the remainder and wrap around the thread in a spiral form. (Figure 16.)

(2) **Loops** are small open places in the thread caused by the excessive length of one or more cocoon filaments. (Figure 17.)

(3) **Long Knots** are knots which have loose ends from six to thirteen millimeters (one-quarter to one-half inch) in length. (Figure 18.)

(4) **Nibs** are small thickened places less than three millimeters (one-eighth inch) in length. (Figure 19.)

(5) **Raw Knots** are the necessary knots for tying breaks in the raw silk thread during the reeling and rereeling operation. The ends of the knot should be less than three millimeters (one-eighth inch) long. (Figure 20.) The number of raw knots should be recorded but they should not be counted among the defects.

Section 5.—**Sample.** The sampling for the test and the sampling of the lot shall be as specified in Part I, Article I, Section 3.

Section 6.—**Winding.** Sufficient silk for the test shall be wound from the sample skeins onto bobbins under the same conditions as specified in the winding test in Part I, Article II, Sections 3 and 4. A record shall be kept of the number of winding breaks and care should be exercised to tie all winding breaks without removing any of the thread, with a distinguishing knot (bow knot) in a manner to be easily recognized. The silk wound onto bobbins in the Winding Test, Part I, Article II, may be used for the Gage Test, provided care is exercised during the Winding Test to tie all winding breaks with a distinguishing knot (bow knot), so that the nature of the defect causing the winding break may be determined and recorded.

Section 7.—**Test.** The bobbins shall be placed upright on the gage reeling machine, and the ends of the threads passed through guides and the gages with just sufficient tension to keep the thread taut. The gages shall be adjusted to such a position that the thread will run through them at the average size. The thread speed should be approximately 230 meters (250 yards) per minute. When the thread breaks, the reel should be stopped and both ends of the thread examined to determine the kind of defect as defined by Section 3 of this Article. If either portion appears fine or coarse it should be tested on a serimeter to determine if it is an evenness defect. (Section 3 A, B, C, D.) When 1000 yards have been

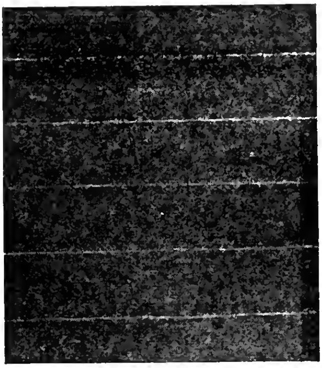


Fig. 16. CORKSCREWS

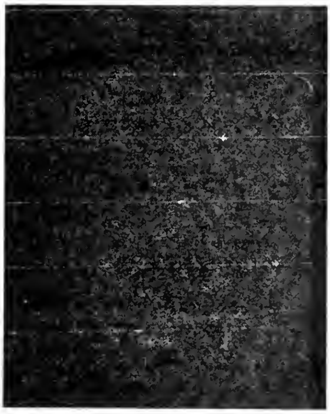


Fig. 17. LOOPS

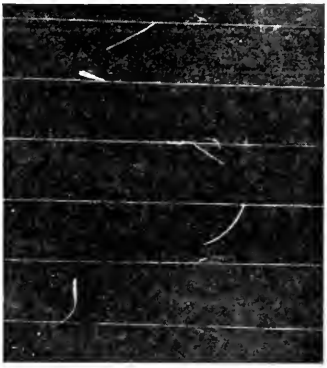


Fig. 18. LONG KNOTS

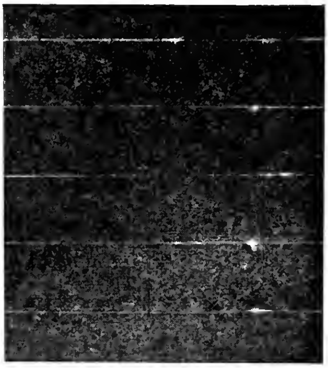


Fig. 19. NIBS

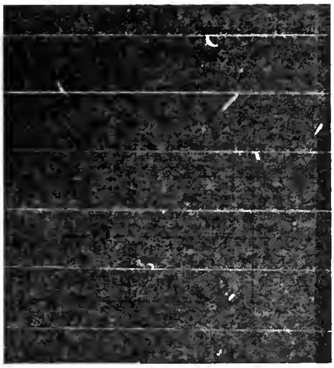


Fig. 20. RAW KNOTS

Figs. 16-20—119

MINOR DEFECTS

wound from each of the ten bobbins (10,000 yards in all) the reel should be stopped and a record made of the number of defects in each class. The test should be continued until a total of 30,000 yards has been reeled, stops and records being made of each 10,000 yards.

Caution—The operator should see that no waste or loose matter collects on the gages to interfere with the passage of the thread and care should be exercised to keep the gages clean, well coated with oil to avoid rusting, and protected with covers when not in use. The gages should be frequently tested to determine if the width of the slit is correct.

Section 8.—**Record.** (Figure 21.) The records of the test shall show the number of each defect for each 10,000 yards reeled and the total number of each defect for the total number of yards tested.

Fig. 21-120

LABORATORY RECORD

Gage Test

Test Number........ Order Number........ Date........ Kind......

Marks................. Bale Number............. Chop............

TEST

EVENNESS

DEFECTS	1st 10,000 Yards	2nd 10,000 Yards	3rd 10,000 Yards	Total For 30,000 Yards
Weak Threads				
Very Weak Threads				
Coarse Threads				
Very Coarse Threads				
Total				

CLEANNESS

MAJOR	Waste				
	Slugs				
	Bad Casts				
	Split Threads				
	Very Long Knots				
	Total				
MINOR	Corkscrews				
	Loops				
	Long Knots				
	Nibs				
	Total				
Raw Knots					

Tested by...............................

ARTICLE II

Serimeter Test for Evenness

Section 1.—**Object.** The Serimeter Test for evenness is made to determine the variation of the breaking points of one hundred different portions of the raw slik thread, from the average breaking point found by taking the average of the hundred portions tested.

Section 2.—**Apparatus.** The serimeter (Figure 83, Part IV) used for the test must be sensitive and capable of being read to one gram and have a maximum capacity of 250 grams. It must be provided with a type of clip which does not cut the thread. The pulling clip of the testing machine shall move at a uniform speed of eighty centimeters per minute.

Section 3.—**Sample.** The sampling for the test and the sampling of the lot shall be as specified in Part I, Article I, Section 3. The test shall be made upon ten sizing skeins.

Section 4.—**Test.** Each sizing skein should be cut once and from each of the ten sizing skeins, ten strands shall be selected at random, and examined to see that they appear to be clean threads (i. e., contain no cleanness defects as defined and illustrated in Part II, Article 1). The strands shall be placed in the serimeter, inspected again to make sure they are clean, and the breaking point determined. Any strands found to contain cleanness defects should be replaced by clean ones and strands which break in the clips should not be counted. The length of thread between the clips at the beginning of each test shall be fifty centimeters (twenty inches).

Section 5.—**Record.** The breaking point of each strand (Figure 23) should be read and recorded to the nearest five grams, the values being arranged in the order of increasing magnitude. The record should show the frequency, i. e., the number of breaks at, above and below the average breaking point.

Note—The following arrangement will be found simple, convenient and easily interpreted. The report blank should have a portion ruled both horizontally and vertically. Each space from the top downward may be taken equal to five grams and each space across the sheet equal to five strands. Assigning values to the spaces vertically, the breaking point of the individual strands may be tallied beside their corresponding values and at the completion of the test the total number of tallies for each breaking point can be entered in an adjoining space. A graphical representation of the result of the test can be easily made by drawing at each breaking point, horizontally from a fixed vertical line, a heavy line with its length indicating the number of strands breaking at that point.

ARTICLE III

Serigraph Test

Section 1.—**Object.** The Serigraph Test is designed to determine the tenacity, elasticity and elongation of raw silk.

Note—As a raw silk thread is pulled, it stretches at first proportionally to the pulling force and if the pulling force is relieved the thread will return to its original length. If the force continues to increase, it will reach a point at which the thread begins to stretch more rapidly and to be permanently stretched.

Section 2.—**Definitions.** The three physical characteristics determined in this test are defined as follows:

Tenacity is the strength of a single thread expressed in grams per denier.

Fig. 23-122

LABORATORY RECORD

Serimeter Test

Test Number........ Order Number........ Date........ Kind......

Marks................. Bale Number............. Chop............

TEST

Breaking Point Grams (G)	Number of Breaks (N)	Product G x N	Frequency Grams	Frequency No.	DIAGRAM
5					
10					
15					
20					
25					
30					
35					
40					
45					
50					
55					
60					
65					
70					
75					
80					
85					
90					
95					
100					
Total Products					
Average Breaking Point					

* This line is average breaking strength line.

Tested by.............................

Computed by.............................

Elasticity is the limiting force expressed in grams per denier which the thread will just support without permanent elongation. It is indicated in the test by the yield point on the serigraph record at which the straight line portion ends and the diagram becomes curved.

Elongation (heretofore called Elasticity) is the amount that the silk is stretched when pulled to the breaking point.

Section 3.—**Apparatus.** The apparatus for the test consists of a tensile strength testing machine with an autographic attachment recording simultaneously the pulling force and the corresponding elongation of the thread. (Figure 85, Part IV.) The machine must be located in a room having humidity and temperature control and must be capable of being tested for correctness of reading by direct loading with standard weights. The total capacity of the machine should not be greater than twice the ultimate strength of the specimen to be tested. The uniform speed of the pulling jaw should be fifteen centimeters (six inches) per minute.

Section 4.—**Sample.** The sample for the test and the sampling for the lot shall be taken as specified in Part 1, Section 3. The test sample shall consist of ten sizing skeins. The 450 meter skeins used in the Sizing Test or the 225 meter skeins used in the American Sizing Test may be used, but in either case, the skeins should not be twisted tight enough to injure the gum and the skeins should be opened and allowed to hang loose for some time before being tested in the serigraph. Sizing skeins which have been used for a conditioned sizing (Part I, Article III, Section 4) cannot be used in this test on account of the possible changes in the physical properties of the thread which may have taken place due to the heating in the conditioning oven.

Section 5.—**Test.** The test skeins shall be placed in a space in which the relative humidity and temperature can be regulated to the standard regain, and they shall remain a sufficient time (usually one to two hours) to allow them to become adjusted to a standard moisture content. Each skein should then be carefully weighed to the nearest one-quarter denier placed in the recording serigraph and tested for tenacity, yield point and elongation.

Note—The skein must be secured in the clamps of the serigraph in such a manner that all strands are held firmly and none of the threads are cut by the pressure of the clamps or any sharp edges. This can be easily accomplished by wrapping all of the strands around a strip of soft cardboard and placing the cardboard in the clamps of the machine in such a manner that all strands are securely held, but not crushed. It is convenient to place the test specimen in the upper clamp of the testing machine first, then carefully draw all of the strands smooth and taut, and wrap them around a second cardboard at the position in which the lower clamp should seize the strands. Caution should be exercised to see that all strands are parallel, uniformly taut, and none excessively stretched.

The length of the tested portion should be ten centimeters (four inches) between the clamps of the machine when the test begins. Care should be exercised to prevent the portion of the skein which is not between the clamps, from supporting any portion of the pulling force.

Section 6.—**Record.** The autographic record should show (Figure 25) a load-elongation diagram from which the load and the elongation at any point during the test can be read with an accuracy of five per cent and the final reading

on the dial of the testing machine should check with the breaking load as shown on the autographic diagram. By placing a ruler along the straight line portion of the diagram, the point at which the diagram begins to depart from a straight line can be marked. This point will be called the **yield point.**

The pulling force at the yield point divided by the number of strands, and by the weight of the skeins in deniers is called the **elasticity of the silk** and is expressed in grams per denier.

The total stretch to the breaking point, divided by the original length is the **elongation** and should be expressed in per cent.

The tabulated record shall show the following:

For each skein:

(a) The number of strands tested
(b) The weight of the skein in deniers
(c) The breaking force in grams
(d) The tenacity, i. e., the grams per denier
(e) The elasticity, i. e., the pulling force in grams per denier at the yield point
(f) The elongation, in percentage.

For the entire test of ten skeins:

(a) The average tenacity
(b) The average elasticity
(c) The average elongation.

Note—It has been found by experiment that the breaking force, in grams, of a number of threads tested together on the serigraph is approximately seven-eighths of the sum of the breaking forces found by testing the same number of threads of the same silk singly on the serimeter.

Fig. 25-124

LABORATORY RECORD

Serigraph Test

Test No......... Order No. .... Date .... Kind ....

Marks .... Bale No. .... Chop............

TEST

Length of Specimen (L)...............centimeters

Number of Strands (N)...............

Skein No.	Weight (W) Deniers	Breaking Force Grams (G)	Tenacity $\frac{G}{WN}$ g. per d.	Yield Point (Y) Grams	Elasticity $\frac{Y}{W \times N}$ g. per d.	Elongation MM	Elongation $\% = \frac{MM}{L} \times 100$
1							
2							
3							
4							
5							
6							
7							
8.							
9							
10							
Total							
Average per Skein (A)							
Average per Strand $= \frac{A}{N}$							

Tested by ....

Computed by........................

Checked by.........................

ARTICLE IV.

Cohesion Test

(By Seem's Cohesion Machine)

Section 1.—**Object.** The Cohesion Test is intended to determine the compactness of the raw silk thread and the thoroughness with which the cocoon filaments forming the thread have been agglutinated. It is based upon the amount of rolling and rubbing under constant pressure which the thread will withstand before splitting into its individual cocoon filaments.

Section 2.—**Apparatus.** The Seem Cohesion Machine (Figure 90, Chapter IV) consists of a hardened steel roller accurately ground and polished, approximately six and one-half millimeters [one-quarter inch] in diameter, mounted on a steel arm which is hinged at one end and which acts as the weight to produce pressure on the roller. Under the roller a steel carriage mounted between guides moves back and forth a distance of about fifty millimeters (two inches.) The carriage is fitted with two clamps for holding the specimens and a counter indicates the number of strokes which the carriage makes during the test. The roller is set at an angle of two and one-half degrees to the path of movement of the carriage, so that the thread is submitted to a rolling and rubbing action.

Note—Great care should be exercised to keep the roller smooth, free from rust or dirt, and to see that it is properly lubricated and adjusted to turn freely but with only slight endwise motion. When not in use, the roller should be covered with a film of vaseline or oil to prevent rusting, but the film must be thoroughly removed with alcohol or gasoline before beginning a test.

Section 3.—**Sample.** The sample for the test shall consist of five skeins and the sampling of the lot is as specified in Part I, Article I, Section 3. The test specimen consists of fifty strands taken at intervals of not more than two meters (two yards) along the thread from a single skein, laid taut, twenty threads per centimeter (fifty threads per inch) on a sheet of firm, unglazed, black cardboard, to which they are secured by means of gummed paper tape. One test specimen shall be prepared from each of five sample skeins and may be taken from the bobbins of the winding test or direct from the sample skein. Raw silk which has been used for a Conditioned Sizing, a Serimeter Test, a Serigraph Test, or any test which affects its physical qualities, shall not be used for the Cohesion Test. Before being used for the test the card should be inspected to determine if the threads have any cleanness defects or pronounced unevenness in the portion which is to be tested. Imperfect threads should be removed before starting the test and in case the strands are noticeably uneven the card should be rejected and another card made.

Section 4.—**Test.** The sample cards should be kept in a standard atmosphere for at least one hour after preparation to insure that the thread is in standard condition. The testing machine should be operated in a room where the relative humidity and temperature can be maintained at standard condition during the test. The test cards should be clamped in the machine in such a manner as to lie flat and smooth and the threads parallel with the direction of movement of the carriage. The machine should run at a uniform speed of 120 strokes per minute, and there should be no evidence of jumping or jerking

at the end of the stroke. As the test proceeds, the threads should be inspected occasionally. As they begin to open, frequent examinations, at least every fifty strokes, should be made to determine when all are completely open.

Note—The openness of the thread can be conveniently determined by removing the card from the machine, inserting a thin piece of metal between the thread and the card and slightly raising the thread off the card.

Section 5.—**Record.** The record of the test should show (Figure 27) the number of cards tested, the number of strokes necessary to open all of the threads on each card and the average number of strokes.

Note—In cases where the threads do not appear to be opening uniformly and a small number (five or less) indicate that they will require a much larger number of strokes to open them, the test may be considered complete when ninety per cent of the threads are open.

Fig. 27-126

LABORATORY RECORD

Cohesion Test

Test Number........ Order Number........ Date........ Kind......

Marks.................. Bale Number............. Chop............

TEST

Number of sample skeins........ Number of strands on card........

Sample Skein	Number Strokes
1	
2	
3	
4	
5	
Total	
Average	

Extremes .... to ....

Tested by ....

PART THREE

Italian, Japanese and Chinese Steam Filature (Shanghai) Raw Silk Based Upon Tentative Standard Tests

This Tentative Classification of Italian, Japanese and Chinese Steam Filature (Shanghai) Raw Silk is promulgated by The Silk Association of America to provide the means for interpreting the results of tests made by the methods and apparatus described in the Standard and Tentative Standard Tests for Raw Silk.

No attempt is made to establish any relation with the present market Classification and it is not intended that this Tentative Classification shall apply to sales contracts under the Raw Silk Rules and Regulations of The Silk Association of America, unless specifically included as special conditions of the sales contract.

Nothing in this Classification shall prevent, in individual cases, the designation of specific characteristics which are especially desired, provided such designation is made in advance of agreement of sale and is made a part of the sales contract.

The limits set in each grade are the minimum requirements which raw silk can show and fall within the grade.

	TESTS	GRADE			
		First	Second	Third	Fourth
Scrigraph	Average *Tenacity,* grams per denier (Note A) over	3.50	3.30	3.20	3.00
	Average *Elongation* percentage over	20%	18%	16%	16%
Gage (30,000 yards)	*Evenness Defects*				
	Average 13 deniers to average 18 deniers not over	5	10	20	30
	Average 18 deniers to average 22 deniers not over	4	8	16	24
	Cleanness Defects				
	Major Defects not over	5	25	50	75
	Minor Defects (Note B) not over	50	100	150	200
American Sizing (225 meter)	Average *Size*—Permissible limits are specified in Raw Silk Rules and Regulations of The Silk Association of America, Amended March 23, 1921, pages 7 10.				
	Range in denier, for the lot (not exceeding 10 bales) (Note C)				
	Average 13 deniers to average 18 deniers not over	3.5	4	5	5
	Average 18 deniers to average 22 deniers not over	4.5	5	6	6

Note A—It has been found by experience that tenacity in grams per denier by the serigraph is very approximately seven-eighths of that found by the serimeter on the same silk.

Note B—If all other characteristics are satisfactory for a grade and the Minor Defects should exceed the limit of the grade, an additional allowance as high as fifty per cent may be made in the Minor Defects.

Note C—Range for 450 meter sizing test should not be assumed as double these values.

The approximate equivalents for 450 meters are:

		First	Second	Third	Fourth
Average 13 deniers to average 18 deniers	not over	6	7	9	9
Average 18 deniers to average 22 deniers	not over	8	9	11	11

APPENDIX A

COHESION

The Cohesion Test is especially important for raw silks which are to be used for raw weaving and it furnishes valuable information for all silks. It is not, however, included, at present, as one of the characteristics upon which the Tentative Classification is based.

The Test is recommended and for those who use it the following interpretation of the results is suggested:

TESTS	GRADE OF COHESION			
	Excellent	Good	Fair	Poor
Strokes: Average of five cards not less than	1500	1300	1100	1000
Strokes: Individual cards not less than	1200	1000	800	600

APPENDIX B

WINDING

Winding is the mill operation by which the raw silk skein is wound onto a bobbin. The winding quality of the silk depends upon the thread and skein formation and is measured by the number of breaks which will occur in winding a measured quantity by the method described in Standard and Tentative Standard Tests. It is not a part of the Tentative Classification of Raw Silk but is graded as an independent characteristic as follows:

TEST	WINDING QUALITY				
	Excellent	Good	Fair	Poor	Very Poor
Winding of 100,000 yards Breaks not over	5	10	20	30	over 30

PART FOUR

SPECIFICATIONS FOR AMERICAN STANDARD SILK SKEIN

Section 1.—**Object.** The specifications for the American Standard Silk Skein are promulgated by The Silk Association of America for the purpose of informing the producers of raw silks regarding the physical characteristics which the raw silk skein should possess, in order to be the most satisfactory to the American consumers. It is essential in American silk mills that the raw silk skeins be uniform in circumference, width and weight; that they be free from reel-arm gums; that the beginning of the raw silk thread be easily and quickly found and that the thread be unwound from the skein with the least possible number of breaks and the smallest possible amount of waste.

Section 2.—**Reeling and Rereeling.** The American manufacturers prefer rereeled raw silk because of its superior winding characteristics, but raw silk may be reeled directly into American Standard Silk Skeins, provided the skein formation conforms to these specifications.

Section 3.—**Reel.** The reel for forming the American Standard Silk Skein shall be from 148 centimeters to 150 centimeters (fifty-eight inches to fifty-

nine inches) in circumference and shall have six arms, uniformly spaced. The arms shall have the outside face upon which the skein rests, rounded in such a manner that the thread touches it for a distance of from one and two-tenths centimeters to two centimeters (one-half inch to three-quarter inch). (Figure 28.)

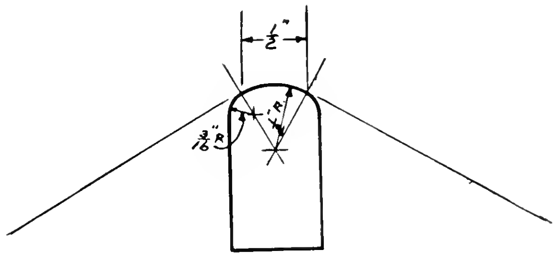


Fig. 28-127. CROSS SECTION OF REEL BAR

Section 4.—**Gum Spots.** Hard gum spots, even if they are small, are very objectionable and should be entirely avoided. The reel bar described in Section 3 will produce much softer gum spots, more easily removed, than the narrow or V-shaped bar which tends to produce small, hard places difficult to rub out without damaging the silk.

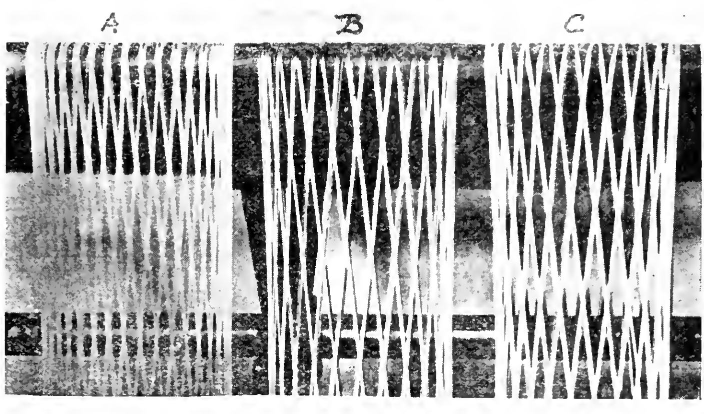


Fig. 29-128. GRANT REELED SKEINS
A has 12 diamonds; B has 8 diamonds; C has 10 diamonds.

Section 5.—**Traverse (Figure 29 and Figure 30, Diagram of Skein Formation).** The guide through which the thread passes onto the reel shall pass to and fro along the reel in such a manner that a definite ratio exists between the revolutions of the reel and the guide of the traverse, so that the thread forms clearly defined diamonds in the skeins. This diamond formation of skein is known as Grant Reeling. There may be from eight to twelve complete diamonds across the face of the skein.

Figure 30 is a diagrammatic sketch of a skein made by 13/24 gear ratio. In such a combination the reel revolves twenty-four times, while the traverse crank makes thirteen revolutions moving the guide of the traverse across the skein and back thirteen times, producing thirteen diamonds.

Section 6.—**Skein** (Figure 31 and Figure 32). The width of the finished skein on the reel shall be eight centimeters (three inches) and its weight shall be approximately as follows:

Note—Care should be exercised to keep all bearings of the gears and connecting rods which operate the traverse in good condition so as not to produce indistinct and imperfect diamonds.

Average Sizes

Fine sizes up to 12 deniers—65 grams to 70 grams (2¼ ounces to 2½ ounces)

13 deniers to 15 deniers—70 grams to 85 grams (2½ ounces to 3 ounces)

Above 15 deniers—85 grams to 100 grams (3 ounces to 3½ ounces)

The skein shall be one continuous thread made by tying all breaks with good, clean knots, with the loose ends cut not more than three millimeters (one-eighth inch) long. The outside end of the thread shall be tied around the skein in such a manner as to be easily found. The skein shall be laced at three places equally spaced with a fine, soft-twisted, cotton or spun silk yarn passed through at least five diamonds in the width of the skein, tied so that the knot is about one centi-

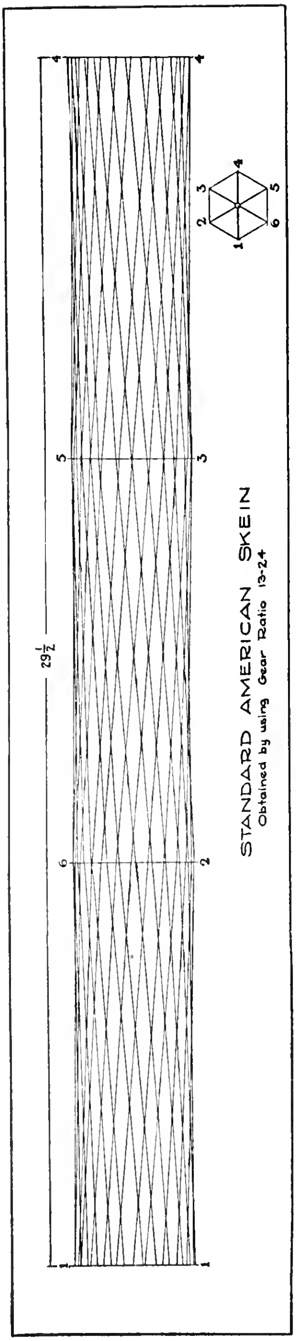


Fig. 30-129. DIAGRAMMATIC SKETCH OF GRANT REEL

meter (one-half inch) from the edge of the skein, and the loose ends cut not to exceed one centimeter (one-half inch) in length from the knot (Figure 31 and **Figure 32**).

Fig. 31-130. GRANT REELED SKEIN LACED IN THREE PLACES

Fig. 32-131. DETAILED LACING OF A GRANT-REELED SKEIN

APPENDIX A

WINDING OF THE AMERICAN STANDARD SILK SKEIN

Section 1.—**Object.** The winding test is intended to show the manner in which the raw silk thread will pass through the winding operation.

(For other specifications see Standard Tests, Sections 2-5 and Appendix A to Tentative Classification)

APPENDIX B

SUGGESTIONS ON REELING MACHINE CONSTRUCTION AND USE

Section 1.—**Object.** The construction of the reeling machine for reeling the American Standard Silk Skein is, as a whole, very simple. The frame and

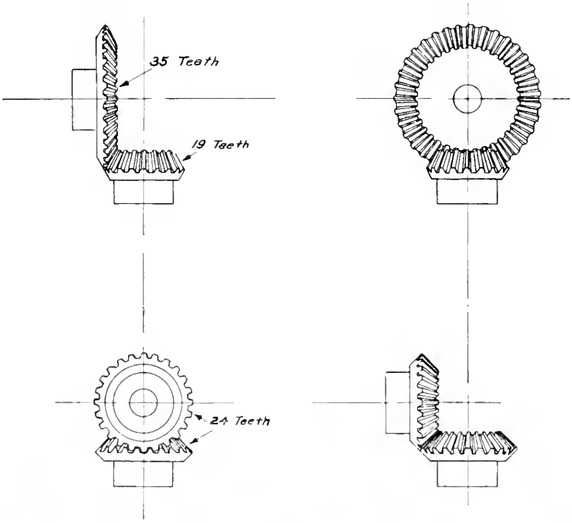


Fig. 33-132. SET OF GEARS

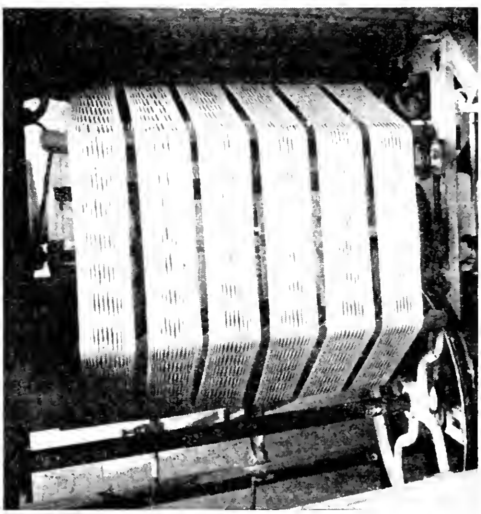


Fig. 34-133. SKEINS MADE BY DIRECT REELING

reel box can easily be constructed of wood, although cast iron frames make a more rigid and stronger machine. The only portion requiring careful attention to design and construction is the traverse, i. e., the guide which directs the back and forth motion of the thread as it is wound onto the reel. These suggestions are intended to call attention especially to the traverse and to show a simple construction which will be cheap, easily built, and effective in operation.

Section 2.—**Traverse.** The diamond in the skein is formed by having the traverse guide move back and forth with a definite number of complete crossings to a definite number of revolutions so that the thread repeats its course on the reel and forms a skein showing well defined diamonds. The traverse mechanism must be positively connected with the axis of the reel and must be driven by it. The essential parts are a reel with a given number of arms a set of gears with a fixed ratio between the teeth (Figure 33) determined by the number of arms and the number of diamonds it is desired to produce, and a connecting mechanism to drive the traverse. Each reel must drive its own traverse (Figure 33).

Section 3.—**Direct Reeling.** Raw silk can be reeled from the cocoon directly into American Standard Silk Skeins (Figure 34) but the skeins produced in this way are generally inferior in formation and winding quality to American Standard Silk Skeins produced by rereeling. The quality of the silk is also improved by rereeling, provided it is properly done with sufficient tension, because it reduces the number of fine ends and some of the other defects.

The apparatus (Figure 35) consists of a reel, traverse and set of gears which will produce a nine diamond skein, three inches wide. The reel bars AA are six in number, the circumference of the reel is one and a half meters (fifty-nine inches) and the reel bars have a cross section as shown at B.

The axle of the reel is fitted on one end with a small pulley which rests on a larger pulley on the power shaft and drives the reel. On the other end is fastened one beveled gear C having twenty-four teeth. The beveled gear D also having twenty-four teeth, engages C and is connected to beveled gear E by the rod F. Beveled gear E has thirteen teeth and engages beveled gear G which has twenty-four teeth. The set of gears C and D are only for the purpose of changing the direction of rotation at right angles to the axis of the reel.

The rod H leads from gear G to the front of the reel box and has on its outer end a crank K with a connecting rod L attached to a pin M in the bar N which carries the guides P which lead the thread on the reel. The connecting rod L should be thirty and one-half centimeters (twelve inches) from center to center of pin holes.

The hole in the connecting rod L through which the wrist pin M passes should be in the form of a slot approximately six millimeters (one quarter inch) greater in length than the diameter of the wrist pin, as shown at R.

It is necessary to keep this entire system in good order and replace parts when they become so worn or loose as to produce imperfect diamonds.

The reel box should be as completely enclosed as possible and maintained at a sufficiently high temperature to dry the thread rapidly. Steam pipes for

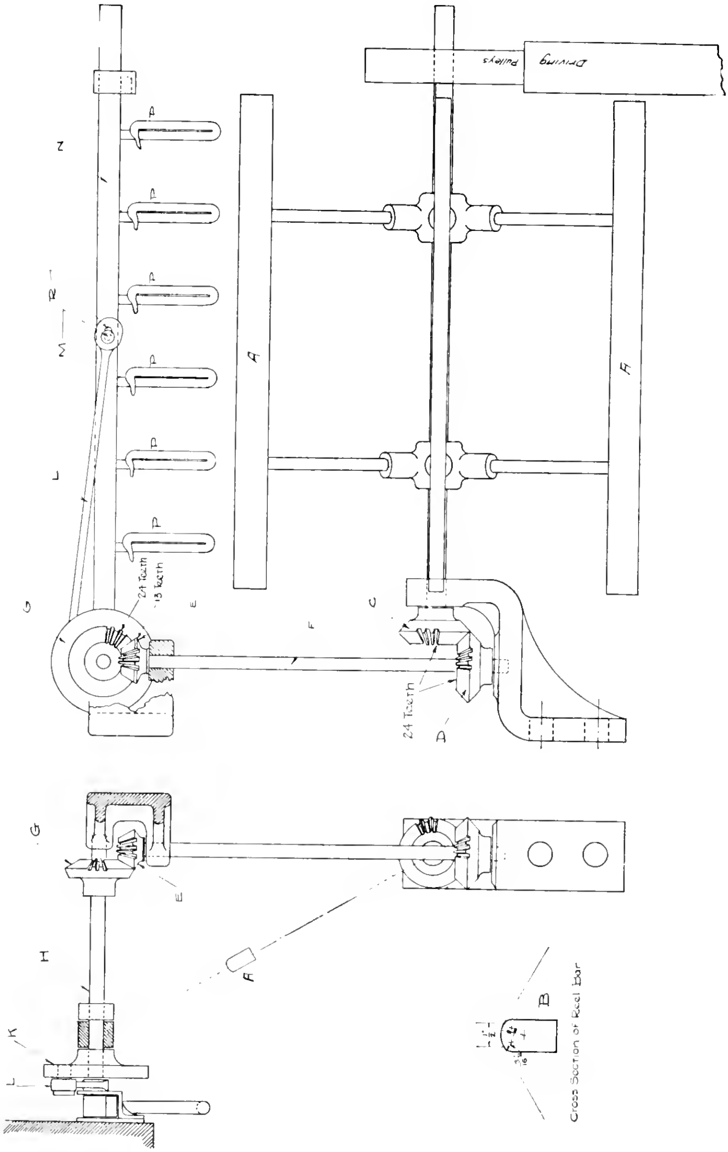


Fig. 35-134. METHOD OF GEARING TRAVERSE AND REEL FOR DIRECT REELING INTO A STANDARD AMERICAN SKEIN

drying should be placed in the bottom of the reel box and it is considered by some desirable to place a steam pipe in the top of the box near the front and near the thread as it enters the box.

Some raw silk skeins show a tendency in the winding in America to separate into rings after a portion of the skein has been wound. It has been suggested that this might be due to incomplete skeins being allowed to stand on the reel and become dry over night.

APPENDIX C

Suggestions on Rereeling Machine Construction and Use

The machine for rereeling may be made the same as the direct reeling machine but it is possible to simplify it and get the same results.

The drawing (Figure 36) shows a rereeling machine in the simplified form.

The axle of the reel is fitted on one end with a small pulley on the power shaft and drives the reel. On the other end is fastened the beveled gear E having thirteen teeth, which engages beveled gear G having twenty-four teeth and connected to crank K.

The rod T is connected with bell crank S which engages with the traverse bar N by rod L.

The rereeling machine should have some means for preventing the formation of double ends in rereeling caused by the broken thread from one small reel becoming attached to that of another small reel and being rereeled with it (Figure 37).

One device suggested in connection with a rereeling machine consists of partitions of thin boards separating the bobbins so that if the thread breaks either as it leaves the small reel or after it passes the tension bar R, the loose end cannot fly against the other threads. Any device which will accomplish the same result will be satisfactory.

The rereeling should be done at sufficient tension to break the fine places in the thread and to form a compact skein. (See last two paragraphs of Appendix B.)

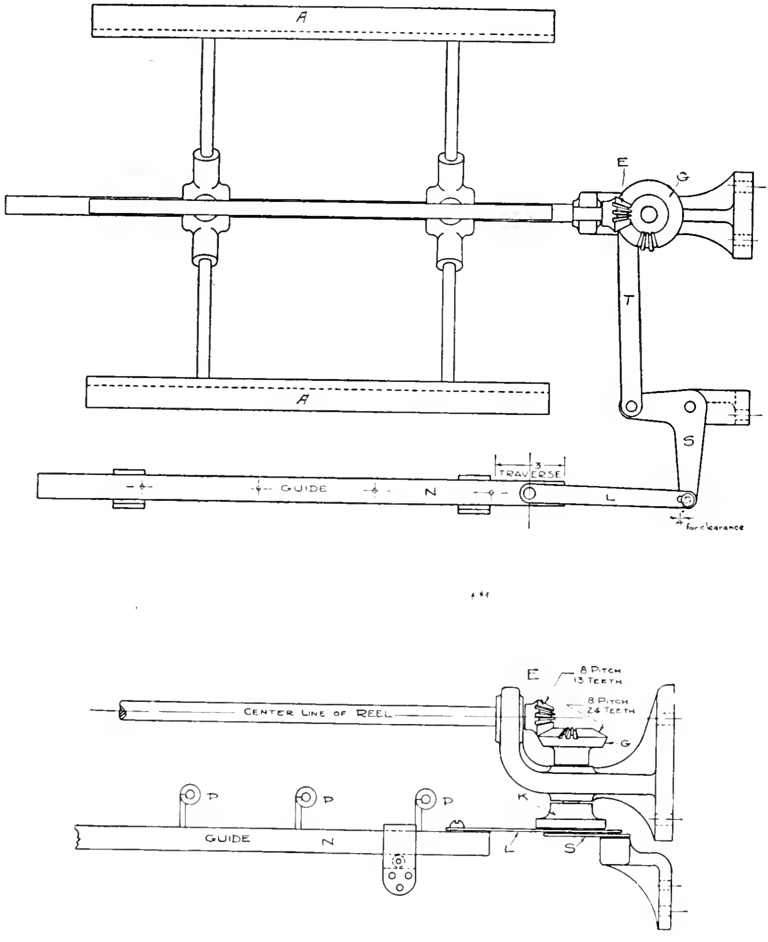


Fig. 36-135. METHOD OF GEARING TRAVERSE AND REEL FOR REREELING INTO STANDARD AMERICAN SKEIN

PERSONNEL

of

Raw Silk Classification Committee

1915-1921

D. E. Douty, Chairman
Albert Bosshard
W. F. Edwards
J. E. Hug*
John H. Jewett
Charles Muller
George A. Post
J. A. Scheibli*
Frederick Schmutz
Warren P. Seem
Charles Cheney, **ex efficio**
Ramsay Peugnet, Secretary

*Members of Committee, 1915-1920.

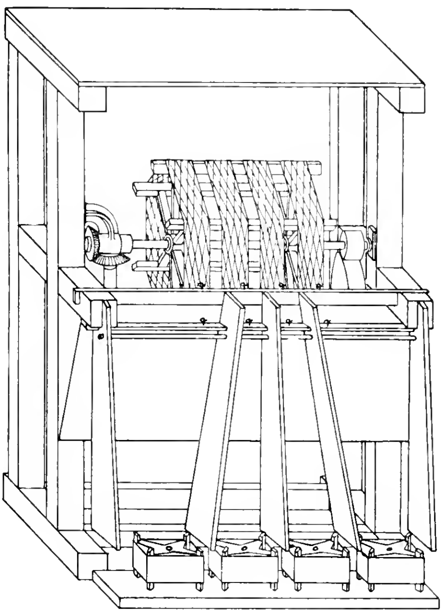


Fig. 37-136. REREELING MACHINE WITH SMALL REELS SEPARATED

As a member of the Raw Silk Classification Committee, I desire to say that while we were not in accord on several principles, the reports represented the best composite method we could present at the time. As a matter of information I present herewith several of the principles wherein my private practice differs from that recommended by the Committee.

(X). W. P. Seem's interpretation of the proposed Tentative Classification by the Raw Silk Classification Committee.—

(O). Seem's method as given in Part II, Chapter III.

Principle A.

(X). That raw silk to constitute a grade must meet the proposed minimum requirements on all characteristics. This virtually means classifying silk on its lowest quality.

(O). That the grades constitute an average of four basic qualities:—Strength, Cohesion, Evenness and Cleanness.

Principle B.

(X). Proposed but four grades, called—First, Second, Third and Fourth. Any silk lower than the fourth on any quality will naturally come within a fifth.

(O). Recommends eight grades, determined by percentage based on common values.

Principle C.

(X). Evenness defects are to be counted as found on 30,000 yards tested.

(O). Evenness defects to be rated according to their effect on evenness, and on the general effect of very fine ends on the working qualities of all fabrics.

Principle D.

(X). Cleanness defects are to be subdivided into Major and Minor and counted as found on 30,000 yards tested. An allowance to be made on Minor defects before reducing the grade.

(O). Cleanness defects are to be rated according to their size and effect on cleanness.

Principle E.

(X). The Serigraph test is recommended to replace the Serimeter, and that elongation be considered as one of the basic qualities.

(O). The strength test is made on Serimeter. Elasticity, now called elongation, is not considered a basic quality as now made.

Principle F.

(X). The range of 225 Metre sizings to be included as a basic quality.

(O). The range of sizing is found to be very unreliable and its use confusing.

Principle G.

(X). The Cohesion test to be held open for further investigation before adopting it as a basic quality.

(O). The Cohesion test is averaged up with the relative value of Tenacity or Strength as representing the physical quality.

INDEX

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FEB 25	1993		
NOV 0 9			
OCT 2	6 1993		
DEC 1 0	1994		